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West African **Land Cover** Reference System



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West African Land Cover Reference System

by

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The West African Land Cover Reference System (WALCRS) is the result of an initiative to take a first step towards a harmonized land cover and an International Organization for Standardization (ISO) based international reference system for creating land cover legend in the region. The regional system has been supported by various projects and organizations such as "Global Transformation of Forest for People and Climate Focus Africa" funded by the Swedish International Development Cooperation Agency (Sida) and through the United States Agency for International Development (USAID) as part of the SERVIR West-Africa programme.

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Abbreviations and acronyms

AGRHYMET	Agrometeorology, Hydrology and Meteorology Regional Centre
ECOWAS	Economic Community of West African States
ISO	International Organization for Standardization
FAO	Food and Agriculture Organization of the United Nations
LCCS	Land Cover Classification System
LCML	Land Cover Meta Language
LCLU	land cover and land use
LCRS	Land Cover Reference System
LCLR	Land Cover Legend Registry
SDG	Sustainable Development Goals
UML	Unified Modeling Language
WALCRS	West African Land Cover Reference System

Foreword

There is a growing need to provide timely and up to date information on the status of land resources all around the world. It is well known that land degradation leads not only to reduced food production, but also to reduced environmental quality, living conditions and health. In West Africa, the most obvious symptoms of the negative impact of land degradation on food production are stagnating and declining yields and increasing levels of poverty. Through a deeper understanding of land dynamics, there is a rising need and interest to strengthen regional collaboration for sustainable development.

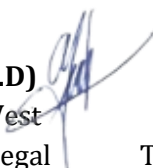
Land cover is a fundamental data theme at the United Nations (UN) and essential for monitoring various Sustainable Development Goals (SDGs) and indicators recognized nationally and internationally. Most West African countries have established national land cover mapping activities over the past decade. However, their integration into a regional system faces challenges related to documentation, accuracy, consistency, comparability, and completeness. Building on international standards and the most recent geospatial advances, it is essential to create a unified regional system to improve integrated land monitoring for all sectors and nations, from local to regional levels.

In partnership with FAO, OSS, AGRYMETH, and SERVIR West Africa, ECOWAS and ECOWAS partner organizations seek to improve crucial information for sustainable and resilient development in the agricultural, forestry, fisheries, and other sectors through the West African land cover reference system. The role of the West Africa regional technical working group on land use has been essential in the success of this regional contribution.

The regional system provides a robust and scientific approach for all partner organizations to use a common framework to monitor land resources, as recommended by the West Africa Regional Conference on Land Use in Africa 2013. It draws on more than fifteen local, national, regional, and international land use exercises relevant to West Africa. We hope that this publication will encourage practitioners, scientists, and policymakers to popularize this classification system, improve land monitoring and better support sustainable and resilient development in the region.

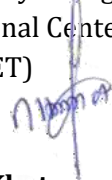
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Executive summary

Assessing and classifying land cover across a variety of spatial temporal scales has become a priority to many disciplines. Land cover and land use is one of the crucial layers recognized by United Nations Global Geospatial Information Management (UNGGIM). This is due to the fact that land cover information has key importance in monitoring natural resources, Sustainable Development Goals (SDGs) and in addressing the requirements of the major multilateral environmental agreements including United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (UNCBD), United Nations Convention to Combat Desertification (UNCCD), the UN forum on Forest. Land cover is also important for other planning purpose including disaster management, risk assessments, green cities, water management, resilient forests, agriculture, urban and rural development, food security and international and national concerned communities.

Unfortunately, the use of the different land cover maps and their integration into a functional system is limited by several constraints including lack of documentation, inconsistency in spatial and temporal resolutions, vague and unclear class description in region, and variation among different classification systems. Over the years, in West Africa, regional experts used various methodologies and systems for land cover classification. These systems comprise Yangambi (C.S.A, 1956), Anderson (Anderson, J. R., 1976), and CORINE (György Büttner *et al.*, 2021). Therefore, there is a need to have a standardised reference framework for land cover classes that can serve as a foundation for other countries, experts, and scientists to build their own user-defined land cover legends and classes.

The purpose of this publication is to provide a harmonized land cover reference system in the West Africa region so that specialists and land cover communities can create their own legends and classes while allowing for future integration. The harmonization process of land cover classes includes classification systems used in the region. This land cover reference system is based on Land Cover Meta Language (LCML), International Organization for Standardization (ISO) based standards. The rules that characterize each node in LCML are controlled by a specific object-based rule that is fully documented and explained in the publication.

This publication is the result of collaboration between Food and Agriculture Organization of the United Nations (FAO), the Economic Community of West African States (ECOWAS), the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), the Agrometeorology, Hydrology and Meteorology Regional Centre (AGRHYMET) and SERVIR West Africa.

1. Introduction

As a result of geospatial technology advancement, the assessment and classification of land cover has emerged as a crucial management tool for a variety of disciplines, providing information on the condition of the earth's surface at different geographical and temporal scales. Information about land cover and natural resources serves multiple purposes and a variety of different applications. Unfortunately, the use of the different land cover maps and their integration into one functional system is limited by several constraints. Some of them such as lack of documentation, inconsistency in spatial and temporal resolutions, accessibility, are well known and several corrective measures can be taken using Geographic Information System (GIS) techniques. Others, mainly related to the semantic interoperability of different datasets as the result of the use of different classification systems, are often underestimated. However, these play a decisive and important role in the correct use and understanding of such information.

In a world that has been standardised, classification systems that are constrained by formats, standards, and a variety of other criteria are all around us. It is this familiarity with classification elaboration that very often creates an improper idea that the process of creating a legend is marginal or minimal in the entire process of production of land information. The creation of a classification or legend, on the other hand, is one of the most sensitive procedures in a mapping activity because it represents a bottleneck where all the enormous efforts to produce information must be presented to the user community and effectively managed into the database. It is the process that attempts to minimise the amount of entropy resulting from the transition from data, such as a satellite image, to information because of a mapping activity.

This is significantly truer in the digital era, as data on land cover and land use (LCLU) is used in a wide range of applications, combined with data from related geographic areas, and combined with other types of data. The issue of harmonisation and semantic interoperability of spatial information has emerged as one of the most significant challenges with the advent of GIS and, consequently, the distribution of more sophisticated and advanced spatial analysis. It is a common practice that many of the descriptions of legends used for land cover mapping are not available, and the classes are not appropriately described, and/or their meaning is vague or ambiguous.

Accuracy assessment is not performed in many cases or experiences several problems due to the difficulty to properly assess the correct delineation of land features due to their vague and unclear definition. In many cases, different classification systems exist within a country or within an organization itself. The consequences of those discrepancies severely affect the proper utilization of vital land information. It must be clear that in a modern digital age, semantic interoperability and data harmonization are not an optional choice but a vital requirement of any mapping activity. Efforts at the national level should be taken to improve data harmonization. Those efforts should consider and benefit from technical advances that science has produced in the last years.

The West African Land Cover Reference System (WALCRS) is an effort to harmonize land cover monitoring in the region. The objective of this document is to present a regional Land Cover Reference System (LCRS) for representing LCLU in the West Africa region. This document will serve as the basis for the development of national and/or regional land cover maps, but also can be used as a reference for various national and/or regional initiatives such as the national forest inventory or the greenhouse gas inventory and other activities that require information about regional, national, and sub-national LCLU.

2. Object based representation of land information

In 2003, after many years of testing of Land Cover Classification System (LCCS) in many different situations and mapping projects, the Food and Agriculture Organization of the United Nations (FAO) submitted the LCCS concept to International Organization for Standardization Technical Committee 211 (ISOTC 211) on Geographic Information as a contribution toward establishing an international standard for LCCS. This was the first time that this ISO committee had addressed a standard for a particular community of interest within the general field of geographical information. All its previous standards had been higher level or abstract standards that established rules for application schema, spatial schema, or similar concepts.

The result was that a standard was first developed to address classification systems in general that is ISO 19144-1 on classification systems and then one to address land cover that is ISO 19144-2, LCML. Both have been approved as official international ISO standards in 2012. The LCML is, therefore, a powerful tool to characterize geographic features in a more modern approach with respect to the conventional methods. According to the LCML model, land cover can be represented using a shared dictionary composed by simple predefined and standardized atomic elements rather than categories. Such elements including tree, shrub, herb, building, and others, can be recombined in different ways to represent different real-world features. The combination of LCML basic objects that represent land cover in a database is then further characterised by additional attributes that are defined as traits and characteristics.

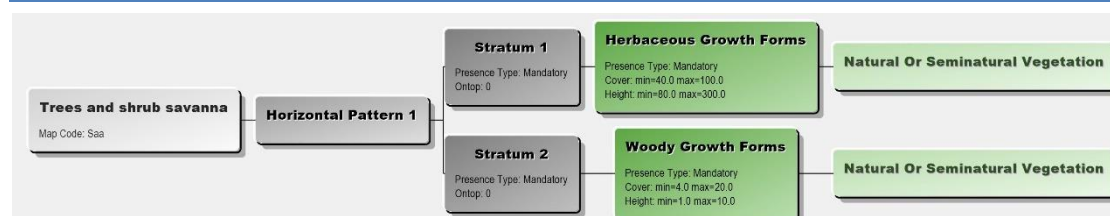
The LCML basic elements or objects, their relationships, inheritance, properties and characteristics associated with them, are formalized in a Unified Modelling Language (UML) class diagram, as part of the standard. Any user, applying LCML rules and conditions, should be able to create compatible legends that will result in object-oriented land cover databases (Di Gregorio, A., 2016b). This can assure integration and semantic interoperability of different data sets derived from local knowledge and/or extensive field analysis such as different local, national, regional, and global legends as well as field observations done without referring to any predefined list of classes.

Land cover categories, in a traditional approach, can still be used but each class is characterized in addition by specific land objects enriched by several additional parametric attributes including percentage of cover, height, persistence of water and others. In this way, the continuum of the real-world information is better captured, not forcing the map producer and hence the end users to adhere to a restricted number of predefined classes. This concept allows land cover community to generate a dynamic land cover database rather than a single dataset.

In addition, in this approach, the meaning of the features is represented by a model rather than a conventional name and text description (see Figure 1). A model, especially when

done with the most up to date modelling languages, is a much more powerful approach to explain the complexity and dynamicity of the real-world. In Figure 1, three basic elements are identified, namely trees, shrubs, and herbaceous growth forms. Properties attached to the basic elements further specify other requirements for cover and height, among other details.

Figure 1. Description of a land cover class for a tree and shrubs savannah



The implications of this process are fully synergistic with the progress of science in modern data management and still with a further possibility of improvements not yet fully exploited. Its intrinsic structure of an open object-oriented system allows not only an unambiguous description of real-world features, more consistent with the logic and structure of modern databases but also enlarges the capability of the system to describe phenomena related to inputs and activities people undertake on a certain land cover feature typical of agriculture and other land uses. LCML not only guarantee great flexibility in the description and/or characterization of land features but in addition:

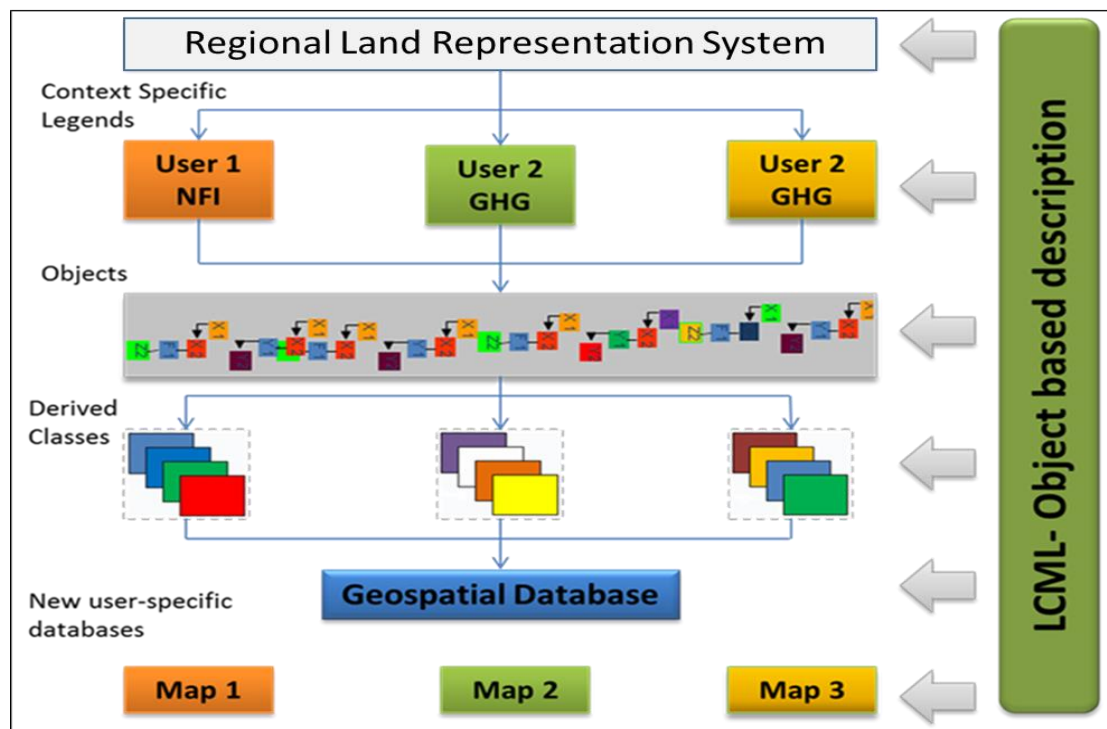
- It standardizes the process of creating the land cover classes.
- It provides a general framework of rules that can be used to create specific legends.
- If implemented, it will bring the land cover community together to create a common understanding of land cover nomenclatures with the aim to produce global, regional, national, and sub-national datasets able to be reconciled at different scales, levels of detail and geographic location.

In 2018 the ISO standard 19144-1 and 19144-2 went through a revision process that applies every five years to all ISO standards. Both were fully reapproved as an international standard. However, FAO, in the intent to always foster an improved process for these standards, has proposed a process of revision of LCML and a new standard for land use that is 19144-3. When ready, these standards will constitute a unified approach to model all the different aspects of the land.

As not all the users are conversant with the UML, and it is also not functional to manually create an UML model for each land feature to be represented in a database. However, the whole concept is supported by a specific software produced by FAO. Land Cover Classification System version 3 (LCCS3) is, therefore, a tool to apply the concepts and rules of the ISO standard LCML. Its use is fast and intuitive, supported by adequate documentation (Di Gregorio, A., 2016a). In addition, it has the capability to be linked with another specific application software called LCCS tool with which the results of the legend generation can be exported in a markup language the XSD format that can be converted into a proper UML schema or ingested into a system for advanced queries of the derived

database. In contrast to conventional methods, the LCML or LCCS is an ergonomic, dynamic method that provides the adequate management of the geographic data. Users can make choices, define, or update data description according to their needs and purpose.

Figure 2. Regional land representation system to support multipurpose land cover and land use activities



3. Land cover in West Africa - an overview

West Africa is a relatively flat low-lying region that is composed of seventeen countries with a total land area of about 8 million square kilometers. The region can be sub-divided based on climate and vegetation characteristics into five ecological belts from the humid southern coast to the Sahara as Guineo-Congolian, Guinean, Sudanian, Sahelian and Saharan belts. These ecological regions play key roles as regional units for land use planning in the region. They are defined according to criteria that integrate various components of the natural and socioeconomic landscapes, namely biophysical factors including climate, geology, hydrology, soils, and vegetation and others and human factors including habitat type, land use and others.

The geological variety is one of the remarkable aspects of West Africa and is composed of ancient Precambrian rock made up of mountain massifs and highlands such as Tibesti, Air, Adrar des Ifoghas and Fouta Djallon. The landscape is characterized by alluvial valleys in Senegal and Ghana, sandy plains, and low plateaus across the Sahel, rolling hills of Togo and rugged mountains with summits reaching over 1 500 m in Guinea and 1 800 m in Niger (CILSS, 2016). Church (1966) reported that these rocks are exposed over about one third of West Africa and are part of the vast continental platform of Africa, which in West Africa has an average elevation of 400 m.

The West Africa region is drained by major rivers including the Niger river, Gambia and Senegal which originate in Guinea's Fouta Djallon highlands. Lake Chad is also a major water body in the region which covers parts of Niger, Chad, Nigeria, Cameroon, and the Central African Republic. The region is characterized by an anticyclonic high-pressure area which is centred over the Sahara and drives the harmattan during the winter months that occurs between December and March (Arbonnier, 2002).

Although nomadic pastoralism is the dominant agricultural system in the Saharan belt of West Africa, crop cultivation is common in other ecosystems, but the types of crops cultivated vary across different ecosystems. For instance, millet and sorghum are the dominant crops in the Sahelian belt, maize, groundnuts, and cowpeas in the Sudanian belt while root crop including cassava and yams and tree crop systems including cocoa, palm trees or cashew trees are dominant in the Guinea and Guineo-Congolian region belts.

Various land cover legends have been designed and implemented for specific research and project purposes over the years (Appendix B). A classification is a fundamental tool to create order and stability for communication of knowledge in a community of users. However, it is important to state that a legend and/or nomenclature is always a local activity. In this context, the term local not only implies the application of an ordered system to a specific geographic area but involves also other parameters such as the group of peoples generating the legend, their knowledge of the study area, the tools used for the map generation as remote sensing data, image processing software and others.

Therefore, there are inevitably many ways to represent and categorize the real world. This can result in a proliferation of many different legends and/or nomenclatures at national and much more at regional level. Any attempt to summarize the various systems used in the West Africa region is inevitably bounded by the variety, diversity, and often difficult accessibility of that information. The present review has analysed different

legends for a total of hundred and forty-five classes with their class descriptions and author institution (see Appendix B). This review is not exhaustive and must be considered as a work in progress because, due to the rapid expansion of land cover projects, there is a proliferation of different types of national and/or regional legends prepared for different types of applications and projects. Many of these LCLU efforts have not originated from a clear understanding of the decision context for which they were intended to inform. Fewer still were designed and deployed with the input of decision makers at the outset.

A general overview of those different legends shows many constraints that refer to the way how the formalization of the meaning of the legend categories is done. From a broad viewpoint, it can be said that as a direct or indirect result of the aforementioned considerations, a systematic comparison of the various nomenclatures performed in the context of a harmonisation process reveals the presence of the same primary issues, which are characterised as follows:

- Synonymy: different terms used for same concepts.
- Polysemy: different understanding of homonymous concepts.
- Risk of class legend overlaps or gaps appearing in databases because of inconsistent definitions of class boundaries on occasion.

This is because in general:

- Class definition expressed by its text description is unsystematic, sometimes ambiguous and/or absent. In many cases, the class name is the sole way to summarise the entire information content. When a text description is present, often, it is limited and not fully reflects the full extent of the original information. The description can be unsystematic because many diagnostic criteria used to build the class meaning are not systematically applied in the same way to all categories of the legend.
- The number of classes is generally fixed and sometimes the classes are too general not able to describe specific important local land cover aspects.

Despite technological advancements in the digital age, the method of representing class meaning is not any more ergonomic. When the real world is represented in categories that are unchanging in nature, it implies rigidity in the dissemination of information from the data producers to the community of end users. End users have limited possibility to interact with the original database, and thus accept the data even though the categories used to represent a geographic area don't entirely meet their demands.

In addition to the general picture represented above, West Africa shows another peculiar aspect. In the region, there is a substance of national and regional nomenclatures, most of the ones of Francophone countries, that directly refers to the vegetation classification called the Yangambi system. The Yangambi vegetation system derives from a Czechoslovak Society of America (CSA) specialist meeting on phytogeography held in Yangambi in 1956 that has been widely used in the sub-Saharan Africa (C.S.A, 1956). Closely looking to this specific context there is a contradicting mixture of positive and puzzling aspects that are mentioned below:

- The fact that a substantial number of nomenclatures directly refers to a well known internationally recognized classification system is for sure a very good step toward a harmonization process.

- However, it is useful, in the framework of fostering a harmonization process, to analyse how this process case by case has been practically done. It is useful to clarify how the original class characterization of the Yangambi system has been practically applied to define the thematic content of some of the categories present in the actual legends of the region.

The remarks based on the review of the Yangambi can be considered as a paradigm on the generation maintenance over the time of classification systems in general. From a practical point of view the migration from a pure vegetation classification to a land cover legend is not always a straightforward passage. Most of the time, the land cover categories utilised in mapping the vegetation are more basic and generic. This is, because of the aim of the final database is different, including the expertise and the mapping methods to generate it. This is reflected in the criteria used to generate and populate the classes of the systems that do not exactly overlap. In addition to these general remarks the Yangambi system has several complexities. Some of them been listed in many scientific publications over the years, that are mentioned below:

- It is an old system created in 1956. Even if the age of a system is not always an undesirable factor, there are some problems in relation to the date of its publications that can create problems. For instance, it is extremely difficult to trace and obtain the original document for consultation. Even so the original text is very brief especially in the description of the different classes. Some of them are just described by the name and nothing else.
- It is not a systematic classification system, but more a tentative description of existing vegetation types of Africa. It implies that the classes are not systematically arranged according to a level of complexity.
- Terms like canopy cover and height are not precisely defined, even when based on physiognomic parameters. As a result, they are open to different interpretations, depending on things like the current numeric range of canopy cover percentage.
- It is a system designed in the pre remote sensing age, therefore, fully, and only tailored to field observations. This reflects on the way, or the importance given to the parameters used to differentiate different classes.
- Many revisions and/or modifications of the internal class arrangement have been proposed through the years. There are therefore numerous original records that have been updated. They are more available than the original one, therefore confusion can be generated between classes listed in the original document and the ones revised.

As a practical result, there is the concrete risk that many classes and sub-classes separations in the national legends have been maintained without consideration of their reflection of locally specific conditions, or their delineation is supported using modern remote sensing technology. This type of database polysemy is difficult to assess and evaluate. The present work is, therefore, intended as practical support to minimize those effects.

4. Regional land cover reference system

The importance and complexity of the creation of a regional Land Cover Reference System (LCRS) are very often underestimated. In many cases different national or regional legends in use are derived from the work of a single national institution that has not considered the development of a common reference system as a real national priority. Direct consequences of this situation are mentioned below.

- Very difficult exchange of land cover and/or forest information between different national institutions and users.
- Reduced efficiency of the national databases.
- Very difficult to update the land cover information.
- Absence of a regional system to which refer for harmonization efforts.
- Loss or inefficient use of financial and human resources.

The availability of international standards is an important step to move forward a common syntax for the rationalization and harmonization of national and regional classification systems. However, the generation of a legend remains a local activity that needs to be put in the proper sub-national, national, and regional context. To create specialised legends that are better equipped to reflect certain applications, various regional and national agencies should follow a consistent regional LCRS as their functional guideline.

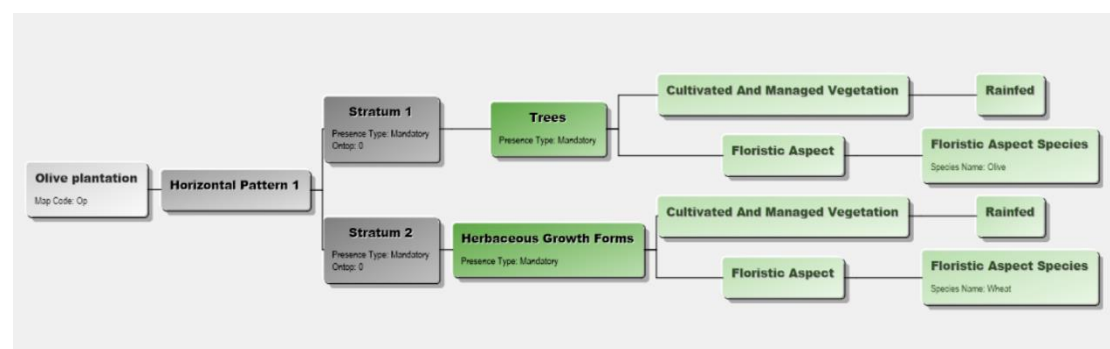
The regional LCRS is somehow different from a simple legend. It is a more thorough collection of land features or a more generic framework that should serve as a reliable guide for various mapping activities. This reference system is represented in a graphical format for a better and easier understanding of the relationship and inheritance level of the different categories. The system aims to represent a comprehensive, distinct, and unambiguous ordering of the land features of a specific geographic area according to a specific object-based point of view. Thus, in the intent to eliminate and/or reduce ambiguities in the definition and comparison of different land features, different mapping agencies dealing with different mapping activities can refer to the representation system to create their specific legends. Those legends can differ between themselves in terms of number and details of their classes according to the purposes for which they have been generated. However, the reference system will assure both harmonization and interoperability of all of them.

The whole logic of the system is based on an object-oriented approach. Each of the categories populating it are constructed according to the ISO standard FAO LCML. The LCML or LCCS syntax works by making available a set of basic standard LCML objects called LCML elements for instance trees, shrubs, buildings, and others, that can be

organized in strata and can be enriched with different types of attributes. These LCML elements act as standardized building blocks and can be combined to describe the more complex semantics of each land cover class in any separate application. Each LCML derived category is represented in a modelling language that is UML. It makes it simpler and more accurate to describe real-world characteristics, and it also makes it simpler to comprehend their ontology and more effective to use them in a sophisticated GIS modelling environment.

For each one of the classes instantiated in the system a LCML/LCCS instantiation model exists in graphical and XSD format and it is stored in the Land Cover Legend Registry (LCLR) using the FAO LCCS3 software (Di Gregorio, A., 2016a). Therefore, when any national and/or international institution wants to use those classes, they just need to refer through the map code to the registry both for the class description and for any other advanced modelling and GIS operations that require the use of XSD markup language.

Figure 3. Model representation of the graphical format of the class multi crop olive plantation

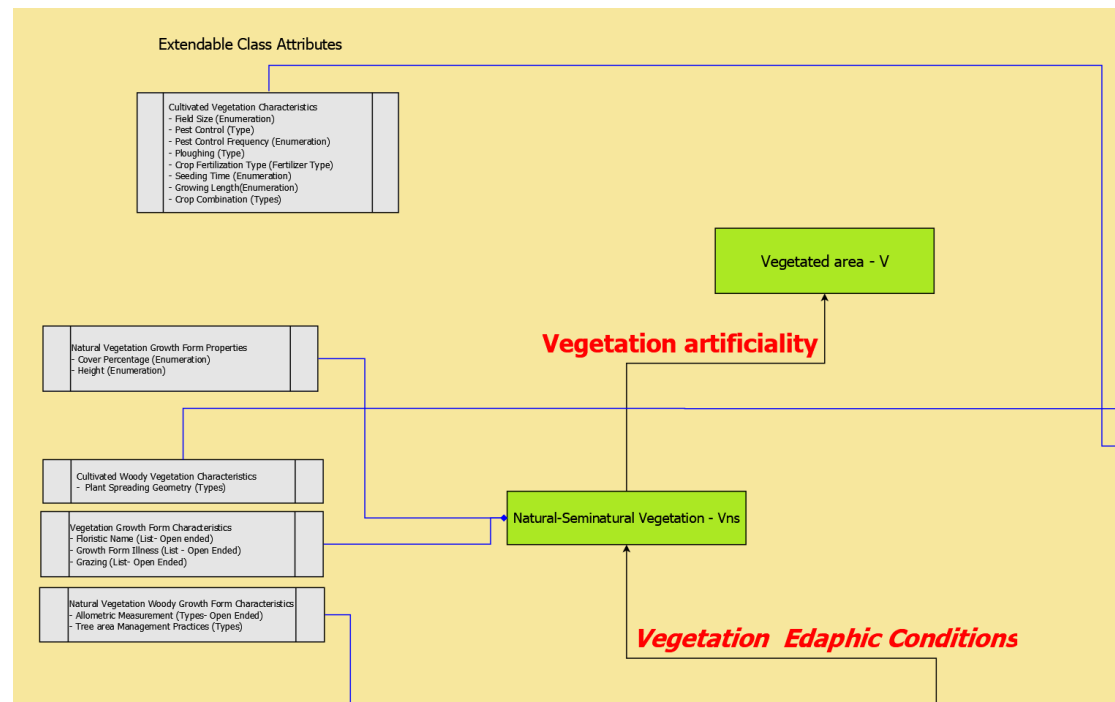


The system has different levels to define land features meta classes and the user has a complete overview of them looking at the overall graphic schema. The system is quite dynamic both in terms of choosing meta classes from many levels as well as in terms of enriching and organising them.

- When building his own system, the user is completely free to use any number of different meta classes from various levels. Since there are no level constraints, each derived legend can be modified in accordance with its own requirements, choosing either a broader or a more specific level for each legend category.
- The classes' instantiated in the system constitute the basic structure of a real-world land feature. They must be considered as a kind of meta classes that can be further expanded according to the needs of specific applications that would require an increased amount of information. This can be done utilizing the LCML shared dictionary of attributes. Those attributes are shown in the graphical model in specific boxes (gray boxes) in Figure 4 for which the link and inheritance with the land features meta classes is graphically documented.

Figure 4 presents examples of the attributes in grey boxes that can be used to further expand the thematic content of the system meta classes in this specific example general class natural vegetation or a more detailed class forest. This list of attributes is a guide to harmonize the further class enrichment and are open ended.

Figure 4. Examples of the land cover meta language attributes



The legend creation including class selection and its specific thematic expansion with extra attributes is very simple and coordinated. The user should load into the LCCS3 software the class/es downloaded from the FAO LCLR, eventually enrich the class thematic content with the desired attributes, all of them listed in the LCCS3 software, and extend the class map code with a user defined code extension, for consistency, it is necessary to start the new extension with a symbol.

4.1. Regional reference system flowchart

The overall flowchart structure (see Figure 12) is composed by three different elements that are mentioned below:

- Different types of meta classes distributed in different levels according to their level of generalization of the land features they represent (boxes with different colours).
- Rules governing in each node the further separation in a more detailed representation of the land features (red text annotations).

- Expandable attribute of the meta classes to eventually further detail specific aspects of the land features (grey boxes).

The graphical schema is presented in form of a flowchart for an easier understanding of most users (see section 6). However, some rules with the specific graphical symbol have been derived from the UML (see Box 1):

- Inheritance (black arrow)
- Association (full diamond)

For an easier and faster consultation of the document the graphical schema (Figure 12) is divided in two coloured sections described below:

- Brighter orange, the meta classes in this section are very basic. Therefore, to make the document easier to consult, they are not represented with the whole class diagram but by only described by the rules governing their sub-division.
- Darker orange, the meta classes are fully described both listing the rules governing the sub-division of the nodes and representing each class according to the LCML approach with a graphical schema.

The rules that characterize each node are controlled by a specific object-based rule that is fully documented and explained in the next sections. The description consists in a specific synthetic text that clearly defines the conditions in terms of presence or absence or relevance of the basic LCML objects and attributes. Overview of the most important aspects of the system can be described in Box 1. A full overview of the system components and their functional relationship is detailed in Figure 5:

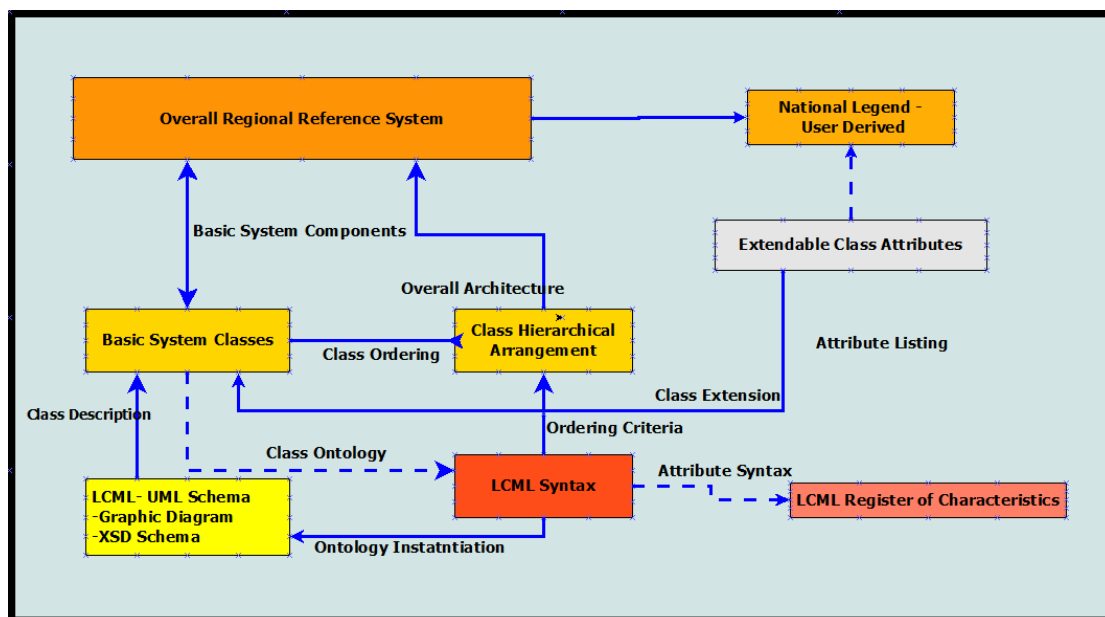
- LCML syntax give the conceptual theoretical base for the built up of the system classes.
- These classes are arranged in different levels to clearly instantiate the class inheritance forming the proposed overall system architecture.
- Each system class is formally described with the most advanced mark-up languages.
- The existing LCML register of characteristics support a list of possible extra attribute that can further expand the class information.

Finally, the whole system will support any type of national legend that can be tailored to specific project needs being at the same time fully coherent with the reference system.

Box 1 Regional reference system for West Africa - rules overview

- The model has been created using a flowchart. However, some rules of the UML have been used: INHERITANCE → ASSOCIATION ◆
- The schema or flowchart IS NOT A LEGEND PER SE but more a graphic reference of how the land cover features is organized and logically ordered in this specific geographic context.
- The definition and ordering of the land cover feature of the schema strictly follow the object-oriented parametric approach as specified in the ISO 19144-2 named as LCML.
- The categories represented in the boxes are, in reality, meta-classes. They represent the basic structure of specific land cover features that can be further expandable using additional attributes using the shared dictionary of terms and attributes of LCML. Green boxes = meta-classes; Grey boxes = expandible attributes.
- Each node of the schema and subsequent lower-level sub-division is regulated by a specific rule that is fully listed and documented.
- Each meta class displayed in the lower level of the schema is defined according to the ISO 19144-2 LCML using the LCCS3 tool.
- To create a user defined legend, the user will define at which level of each feature (meta class) he or she wants to stay, no restriction of level exists, as for instance, in a level based traditional hierarchical legend. For each specific feature to be a part of a legend one can choose any level or detail, for instance a very generic one for feature A and a very detailed one for feature B. As specified at point 2, those classes can be further expanded.

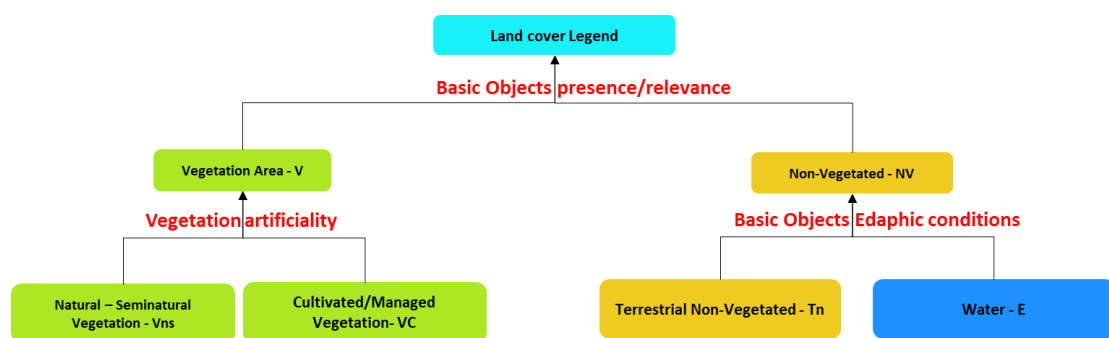
Figure 5. Overview of system components and their functional relationships



5. Rules for the meta class arrangement

To represent the variety of West African land features, the regional land representation system is divided into different distinct levels. These levels have been created according to the number of details required to represent the overall land features of the region and are described according to the object-oriented rules and syntax of the LCML. The LCML uses a physiognomic or structural method that is improved with additional qualitative criteria to characterise and/or classify land features. The whole set of LCML elements and attributes are part of the LCML shared dictionary that guarantee a full interoperability and harmonization of the derived land features. Each of these levels are defined according to specific rules that are fully listed and described below.

Figure 6. Separation of land features at basic level



5.1. First and second level in land features

Main separation of the basic land features according to the following conditions:

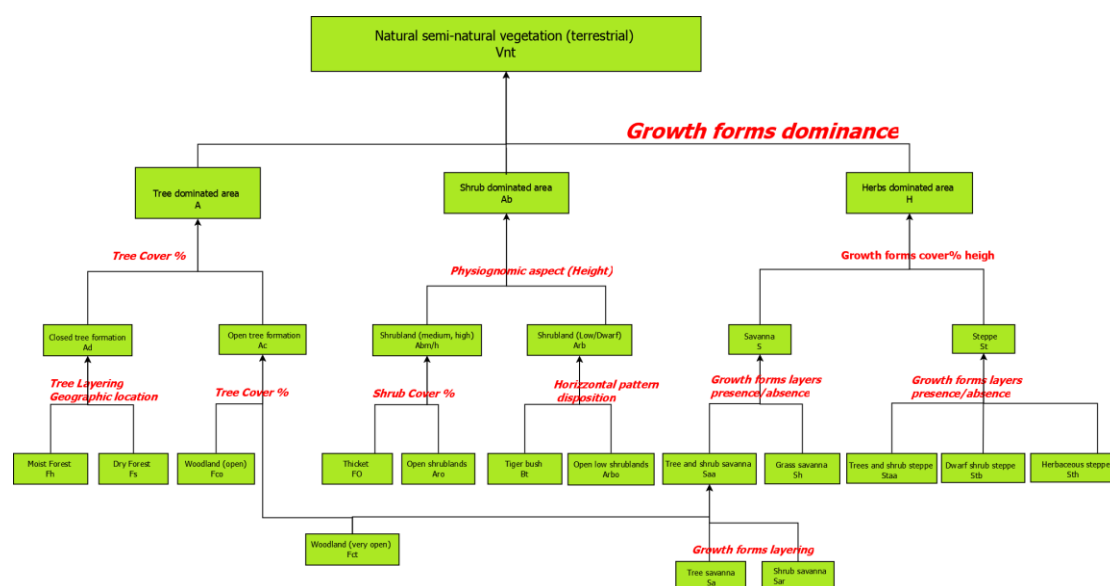
- **Basic objects presence or absence:** the area is sub-divided in two main groups vegetated surface and abiotic surface. The first group is defined by areas that have a vegetative cover of at least four percent for at least two months of the year. This cover may consist of woody life forms including trees and shrubs, herbaceous life forms including forbs and graminoids and/or a combination of them. On the contrary, any surface having less than four percent ($< 4\%$) of vegetated growth forms belong to the other group.

- **Vegetation artificiality:**

(A) Natural vegetation is defined as an area where the vegetative cover is in balance with the abiotic and biotic forces of its biotope.

Semi-natural vegetation is defined as an area where the vegetation is not planted by humans but influenced by human actions. These may result from grazing, possibly overgrazing the natural phytocoenosis, or else from practices such as selective logging in a natural forest whereby the floristic composition has been changed. Previously cultivated areas that have been abandoned and where vegetation is regenerating are also included. Another example is the secondary vegetation that grows during the fallow time of shifting cultivation. The human disturbance may be deliberate or inadvertent. Hence, the term semi-natural vegetation refers to vegetation that has been affected by humans but has recovered to the point where the species composition and environmental and biological processes are either identical to, or in the process of obtaining, their undisturbed state.

Figure 7. Natural seminatural vegetation



(B) Cultivated and Managed Vegetation is defined as an area where the natural vegetation has been removed or modified and replaced by other types of vegetative cover of anthropogenic origin. This vegetation is artificial and requires human activities to maintain it in the long term. Between human activities, or before starting crop cultivation, the surface can be temporarily without vegetative cover. Its seasonal phenological appearance can be regularly modified by humans for example tillage, harvest, and irrigation. All vegetation that is planted or cultivated

with an intent to harvest is included in this class for example wheat fields, orchards, rubber, and teak plantations.

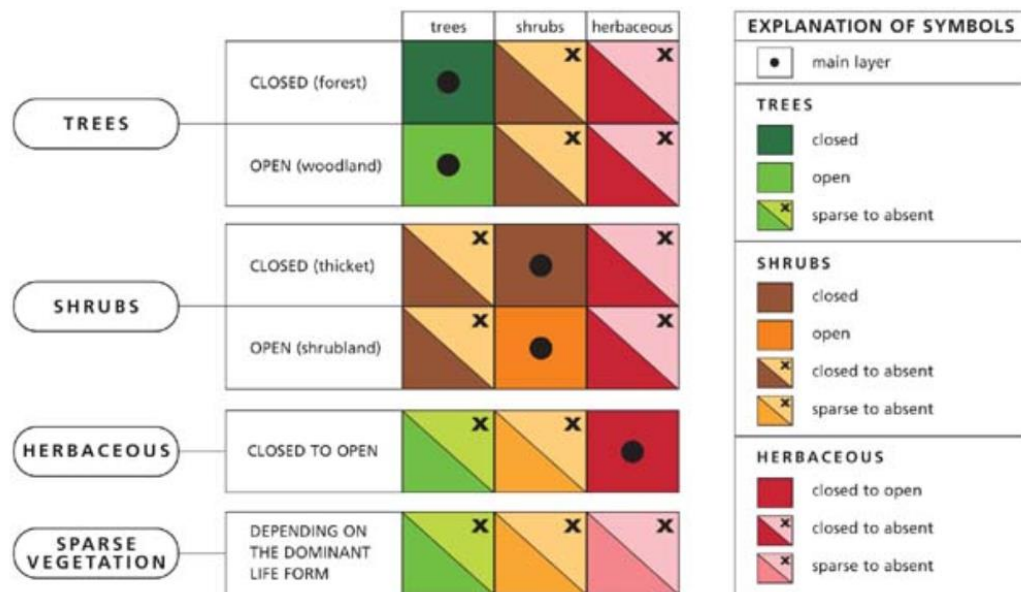
- **Basic objects (abiotic surfaces) edaphic conditions:** it refers to the presence or absence of water or other physical appearance of it. Water may not be present all year round.

5.2. Natural seminatural vegetation

Description of the rules governing the sub-division of the natural seminatural vegetation terrestrial:

- **Natural seminatural vegetation edaphic conditions:** it describes areas that are transitional between pure terrestrial and aquatic systems. In the second case, the vegetative cover is influenced by the presence of permanent water, or the water table is usually at or near the surface or the land is covered by shallow water. The predominant natural vegetation, at least periodically, comprises hydrophytes. Marshes, swamps, bogs, or flats where drastic fluctuations in water level or high concentration of salts may prevent the growth of hydrophytes are all part of this class. Occasionally flooded vegetation within a terrestrial environment is not included in this class.
- **Growth forms dominance:** it defines the main domain that characterizes a specific vegetated area. Following the major structural vegetation classifications worldwide the main criterion is characterized by uppermost canopy layer logic. This means that the dominant layer goes from woody life forms that is tree or shrub or woody canopy to herbaceous life form that is forbs or graminoids.
- This general rule is subject to a **sub-condition of cover:** It is only valid if the dominant life form has a cover from 10 to 100 percent that is closed to open. If the life form is less than 10 percent (< 10%) that is sparse, the dominance goes to another life form that has a closed or open cover (see Figure 8).
- **Tree cover percentage:** the cover defines the proportion of a particular area of the ground, substrate or water surface covered by a layer of plants, considered at the greatest horizontal perimeter level of each plant in the layer.
- **Physiognomic aspect height:** it defines the height of a layer of a growth form expressed in meters. The height of a certain layer is measured from the ground to the average top of the life form being assessed. The fact that single plants of one synusia differ from the average height can be ignored, apart from the fact that they can form their own layer that is strata.
- **Growth forms cover percentage and height:** it refers to the cover percentage and height of the herbaceous growth forms (see the definitions above).

Figure 8. Sub-division of the natural seminatural vegetation terrestrial



- **Tree layering and geographic location:** layering or stratification refers to the vertical disposition of a certain life form. The geographic location, in this case altitude expressed in meters above sea level, refers to the general location of a certain feature.
- **Shrub cover percentage:** see above.
- **Horizontal pattern disposition:** it defines the macro pattern of vegetation formations, defined as the horizontal spatial distribution of vegetation in a certain area. It should not be confused with cover, which defines the spatial arrangement of life forms for example trees and shrubs. A horizontal pattern may be used for a complex land cover class composed by two or more distinct land cover features that will be handled as a unicum independently from scale constraints
- **Growth forms layer presence or absence:** it defines the presence or absence of different growth forms strata.

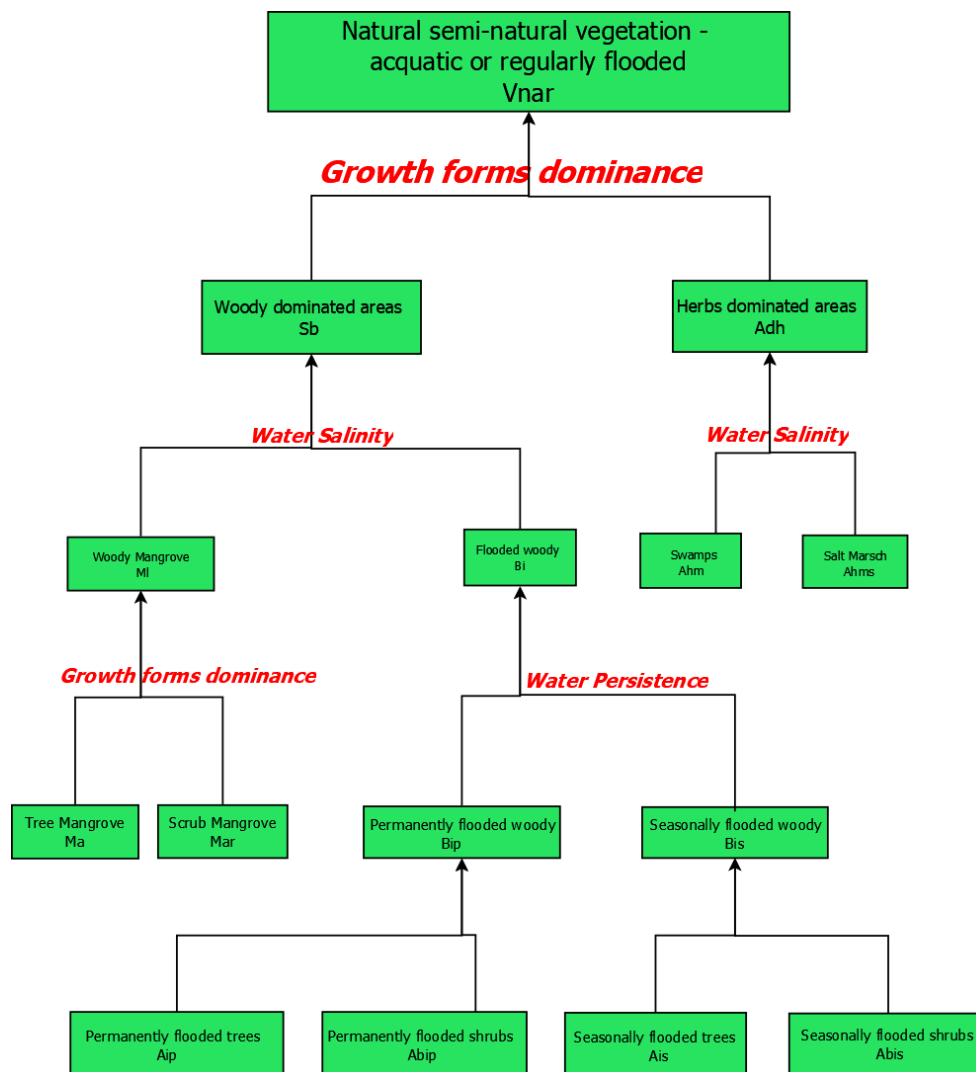
5.3. Natural seminatural aquatic or regularly flooded vegetation

Description of the rules governing the sub-division of the natural seminatural aquatic or regularly flooded vegetation are as follows. The structure of natural and seminatural aquatic or regularly flooded vegetation is provided in Figure 9.

- **Growth forms dominance:** see section 5.2.

- **Water salinity:** it refers to the concentration of Total Dissolved Solids (TDS), expressed as part for millions in the water.
- **Water persistence:** it refers to the length on which the water remains in a specific area.

Figure 9. Natural seminatural aquatic or regularly flooded vegetation



5.4. Cultivated and managed vegetation

Description of the rules governing the cultivated and managed vegetation are described below. Structure of cultivated and managed vegetation is provided in Figure 10.

- **Water supply:** it refers to the main watering regime of a specific crop if it relies on rainfall or on artificial.
- **Growth form dominance:** see section 5.2.

- **Waterbody persistence:** it refers to the presence and duration of water supply for the growing of a specific crop.
- **Plantation types:** it refers to distinction made between forest plantations that is plantation of woody plants done for timber or other type of purposes that imply the harvest of the plant after a certain number of years and orchards. And other types of plantations that is plantation of woody plants done for the regular harvest of fruits or other goods. The plants are permanent.
- **Plant stratification:** it refers to the presence/absence of one or more additional layers of growth forms in addition to the main one.
- **Crop cultivation period:** it refers to the length on which a land is covered by crops in the growing season.
- **Cropping intensity:** it refers to the number of harvests of annual crop (s) within one year.
- **Leaf phenology:** it refers to the general behaviour of woody plants throughout the year. A distinction is made between:

Evergreen: perennial plants that are never entirely without green foliage.

Deciduous: perennial plants that are leafless for a certain period during the year.

Leaf shedding usually takes place simultaneously and in connection with the un-favourable season.

- **Crop stratification:** it refers to the simultaneous presence or absence of two or more layers of crops.
- **Crops occurrence:** it refers to the presence/absence of a crop during the yearly cultivation period.
- **Evergreen:** perennial plants that are never entirely without green foliage (Ford-Robertson, 1971).
- **Horizontal pattern disposition:** it refers to the spatial combination of different land features that form a unicum.

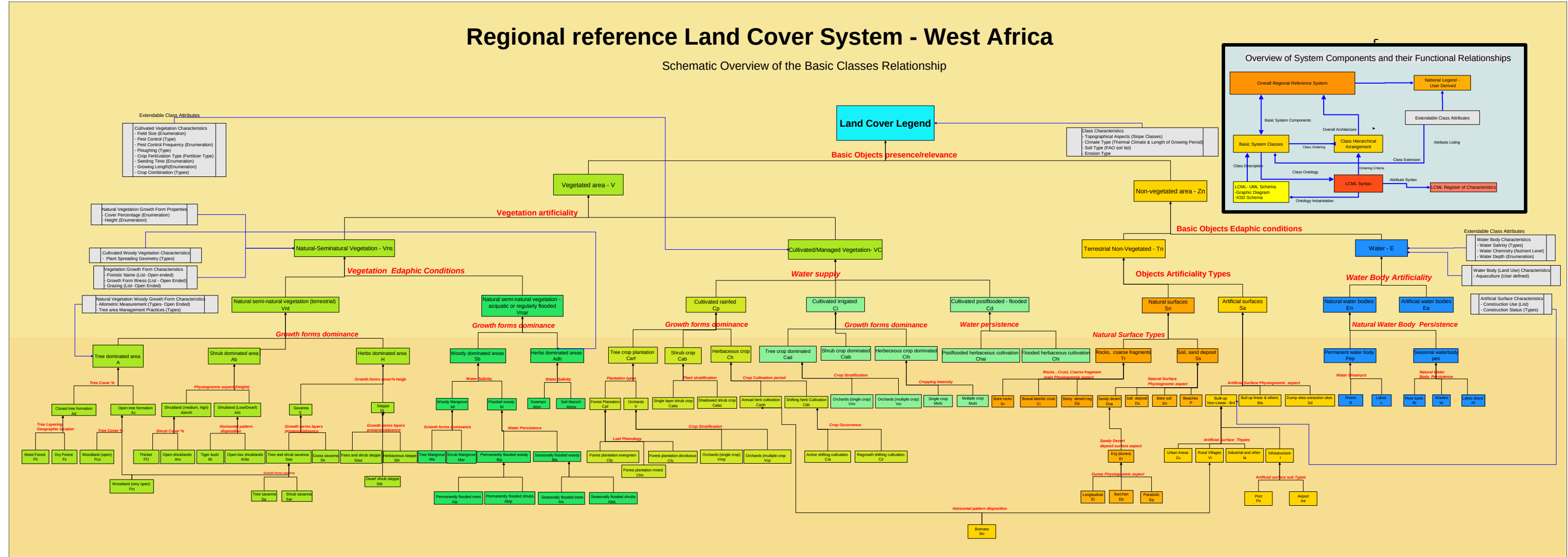
- ### Figure 11. Terrestrial non vegetated and water and associated areas



6. The West African land cover reference system

The WALCRS is based on 3 levels, these levels and their relationships are described in detail in chapter 5. The whole schema is divided into major categories that is vegetated (biotic) and non-vegetated (abiotic). The vegetated category is further categorized into natural and cultivated and non-vegetated into terrestrial non-vegetated and water. In the upper right corner of the schema, concepts and their functional relationship can be seen while in the white boxes, attributes for class expansion can be seen. Complete class list with the description and photograph can be seen in appendix A. Detailed steps are available in appendix C for users to use this schema and create their own legend based on their requirements.

Figure 12. Schema for West African land cover reference system



7. Using the West African land cover reference system

As specified in other sections of this document, the West African Land Cover Reference System (WALCRS) is not a legend per se but more a systematic overview of the different land cover aspects of the region represented and ordered according to an “object oriented” logic using the ISO standard 19144-2 LCML. Therefore, any user that wants to prepare its own sub-national, national, or regional legend has to follow a particular procedure. This section describes the different easy steps to be done. Those activities can be by (1) understanding the overall structure of the regional system and selection of the classes that will be part of the legend, and (2) using LCCS (see Appendix C).

Step 1 – Understanding the overall structure of the system

The schema is divided in different levels starting from the more general to the more detailed ones. In each level the land cover features are arranged in meta-groups. The built-up of each group and its position in the schema is regulated by specific rules that are clearly listed in the document (see section- 5 for details). It is important for the user to understand those rules because they give a clear picture of the reasons why some classes are grouped in a certain way and not the other.

Step 2 – Select the classes needed for a specific legend

Looking at the general schema (link will be added) the user can select the classes with which user wants to populate his own legend. There are different levels from the more general to the more detailed one. The user is free to navigate inside the schema selecting for instance a class of vegetation at the very detailed level of the system and another one of agriculture at a more general level. The user must remember that those are meta-classes that can later be further eventually customized according to specific needs.

Step 3 – Understanding the meaning of each selected class

When a set of classes have been selected, it is important that the user fully understand their meaning. This can be done looking in Appendix A to the full description of each class. The user will also find specific indications on how the meaning of those meta-classes can be further expanded.

Step 4 - Loading the LCCS regional file

The whole classes represented in the graphical schema are built up and recorded in the FAO LCCS3 software. LCCS file can be downloaded from the FAO LCLR (FAO, 2021).

Step 5 - Creation of the user defined legend

The user-defined legend can be created just by doing a copy-paste of the selected classes into a "New Legend" created in the LCCS3 software.

Step 6 - Further customization of the legend classes

When the specific user defined legend has been created, the user can act in each single class to add or refine specific class details. When an original meta-class is modified, to assure harmonization with any other legend derived from the same system it is important to maintain the original map code followed by an extra code symbol for example original map code for Steppe (meta class) is "St" and code for Steppes arborée et arbustives map code should be "St(aa)". In this code "**St**" is the original code while "**aa**" is added for the expanded/new class that is original meta-class code (new code) - > St(aa).

Conclusion

This is the first land cover reference system developed for West Africa. The regional land cover reference system represents the structural form that was developed as a system to describe the features most likely to be found in West Africa, in collaboration with international and regional institutions. The system attempts to instantiate all these basic requirements in an innovative logical framework adapted and refined for West African countries. To better understand the concept of the system, it is important to analyse its structure and the functional relationship of the different elements. The definition of the classes used in the regional system is clear, precise, and based on objective criteria. These classes are meta-classes and can be extended if necessary.

The system, thus, offers the possibility of a regional framework for land cover while ensuring interoperability between different derived classification or legends developed by different countries or different ministries and for different purposes. The system is designed to be flexible enough to adapt and evolve with needs. In addition to creating specific legends for different applications, the system can also be used to make comparisons with other existing classifications. Furthermore, the land cover legend reference system for West Africa offers promising potentials for integrating land cover monitoring and field data collection initiatives for one of fundamental geospatial data themes.

References

- Anderson, J. R.** 1976. *A land use and land cover classification system for use with remote sensor data* (Vol. 964). US Government Printing Office. <https://doi.org/10.3133/pp964>
- Arbonnier, M.** 2002. *Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest*: Editions Quae
- Church, R.J.** 1966. *West Africa: a study of the environment and of man's use of it*: Longman's, Green and Co., Ltd
- CILSS.** 2016. *Landscapes of West Africa: A Window on a Changing World*. Earth Resources Observation and Science Centre, U.S. Geological Survey. Available online: https://edcintl.cr.usgs.gov/downloads/sciweb1/shared/wafrica/downloads/documents/Landscapes_of_West_Africa_Atlas_high_resolution_en.pdf
- C.S.A., 1956.** Conseil scientifique pour l'Afrique au sud du Sahara. Phytogéographie phytogeography. Réunion de spécialistes du C.S.A. en matière de phytogéographie. Yangambi (28 juill.43 août 1956), Londres, Publ. Bureau C.C.T.A., 53 p., 10 fig.
- (publ. C.S.A. no 22).**
- Di Gregorio, A.** 2016a. *Land Cover Classification System: User manual. Software version 3*. Rome, Italy, Food and Agriculture Organization of the United Nations. <https://www.fao.org/3/i5428e/i5428e.pdf>
- Di Gregorio, A.** 2016b. *Land Cover Classification System: Classification Concept. Software version 3*. Rome, Italy, Food and Agriculture Organization of the United Nations. <https://www.fao.org/3/i5232e/i5232e.pdf>
- FAO.** 2021. *FAO-LCLR - Datasets - "FAO catalog" [online]*. [Cited 31 May 2022]. <https://data.apps.fao.org/catalog/dataset/land-cover-legend-registry>
- FAO.** 2020. *Land use/land cover and forest cover mapping in Nigeria. Abuja*. <https://doi.org/10.4060/cb1327en>
- FAO.** 2005. *Rehabilitation of tsunami affected mangroves needed [online]*. [Cited 6 June 2022]. <https://www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/272518/>
- György Büttner, Kosztra, B., Maucha, G., Patak, R., Kleeschulte, S., Hazeu, G., Vittek, M., Schröder, C. & Littkopf, A.** 2021. CORINE Land Cover Product User Manual (Version 1.0). Copernicus Land Monitoring Service: 129. (also available at <https://land.copernicus.eu/user-corner/technical-library/clc-product-user-manual>).

OSS. 2019. *Sahel and West Africa - Atlas of land cover maps - Strengthening Resilience through services related to innovation, communication, and knowledge - BRICKS (Benin, Burkina Faso, Chad, Ethiopia, Ghana, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan and Togo.*

Appendix A - Land cover groups and classes in West Africa

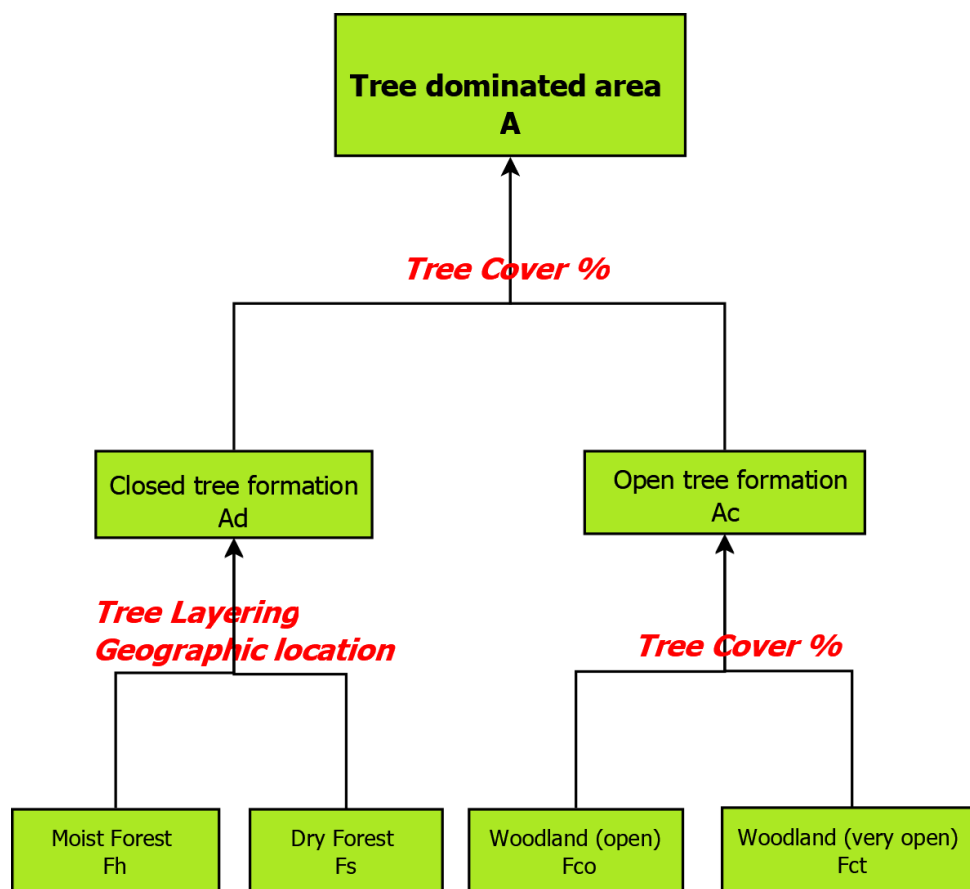
Section I

Natural semi-natural vegetation (terrestrial) - Vnt

Tree dominated area – A

It corresponds to areas with natural semi-natural vegetation where the growth form tree is dominant. The cover percentage of the element tree is less than 20 percent that is cover ranging from 20 to 100 percent. The presence of other woody (shrubs) or non woody (herbs) growth forms is recognized with any cover percentage.

Figure 13. Structure of tree dominated areas



Derived classes (first level)

Two derived classes are foreseen classified as closed tree formation and open tree formation (woodland), sub-divided according to the different cover ranges that characterize the dominant element tree.

Closed tree formation (Ad)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element tree. The element tree has two attributes:

- Cover expressed in percent of plant covering the ground ranging from 70 - 100 percent.
- Vegetation artificiality in this case is defined as natural vegetation.

Open tree description (Ac)

This class is very basic, and generic being constituted by one mandatory strata that defines the overall class aspect. The strata are constituted by one basic element tree. The element tree has two attributes:

- Cover expressed in percent of plant covering the ground ranging from 20 - 70 percent.
- Vegetation artificiality in this case is defined as natural.

Derived classes (second level)

A further sub-division is made both for the closed and open tree formation. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Moist forest - Fh

Picture



Description

This class describes the generic aspect of a so-called moist forest. It is constituted by one mandatory stratum that defines the overall class structure. The strata is constituted by one basic element tree. The element tree has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 70 to 100 percent.
- Height expressed in meters ranging from 8 to 25 meters.
- vegetation artificiality in this case defined as natural.

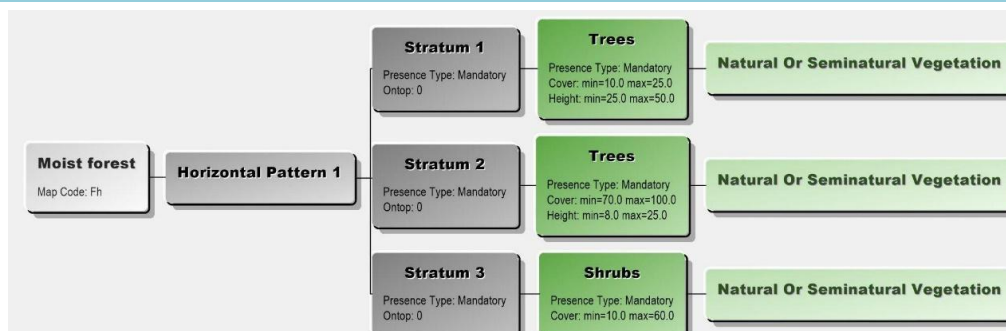
A strata of basic element tree emergent from the main strata is present with the following attributes:

- Cover expressed in percent ranging from 10 to 25 percent.
- Height expressed in meters ranging from 25 to 50 meters.
- Vegetation artificiality defined as natural.

An extra strata of basic element shrub with the following attributes:

- Cover expressed in meters ranging from 10 to 60 percent.
- Vegetation artificiality defined as natural.

LCCS diagram



Dry forest - Fs

Picture



Description

This class describes the generic aspect of a so-called dry forest. It is constituted by one mandatory stratum that defines the overall class structure. The strata is constituted by one basic element tree. The element tree has two attributes:

- Cover expressed in percent of plants covering the ground ranging from 70 to 100 percent.
- Height expressed in meters ranging from 8 to 30 meters.
- vegetation artificiality in this case defined as natural.

A strata of basic element shrub with the following attributes:

- Cover expressed in meters ranging from 10 to 50 percent.
- Height expressed in meters ranging from 4 to 5 meters.
- Vegetation artificiality defined as natural.

LCCS diagram



Woodland (open) - Fco

Picture



Description

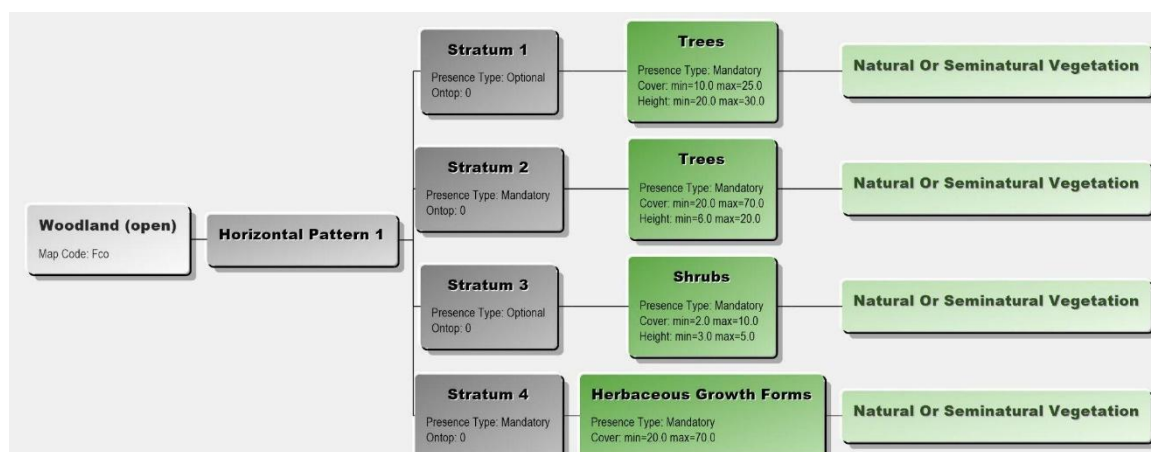
This class describes the generic aspect of a so-called open woodland area. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element tree. The element tree has two attributes:

- Cover expressed in percent ranging from 20 to 70 percent.
- Height expressed in meters ranging from 06 to 20 meters.
- Vegetation artificiality defined as natural.

A strata of basic element herb with the following attributes:

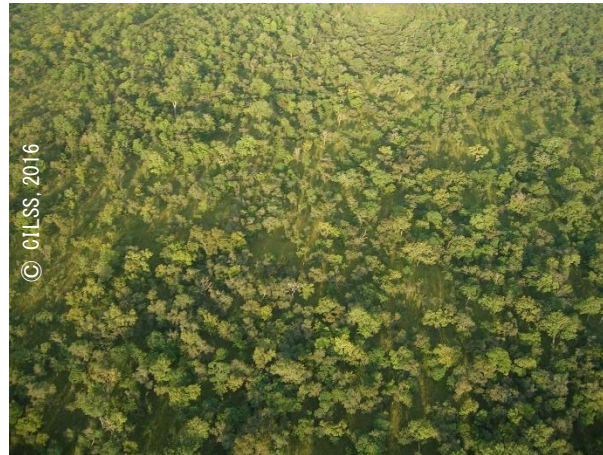
- Cover expressed in meters ranging from 20 to 70 percent.
- Vegetation artificiality defined as natural.

LCCS diagram



Woodland (very open) - Fct

Picture



Description

This class describes the generic aspect of a so-called very open woodland area. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element tree. The element tree has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 40 percent.
- Height expressed in meters ranging from 6 to 15 meters.
- vegetation artificiality in this case defined as natural.

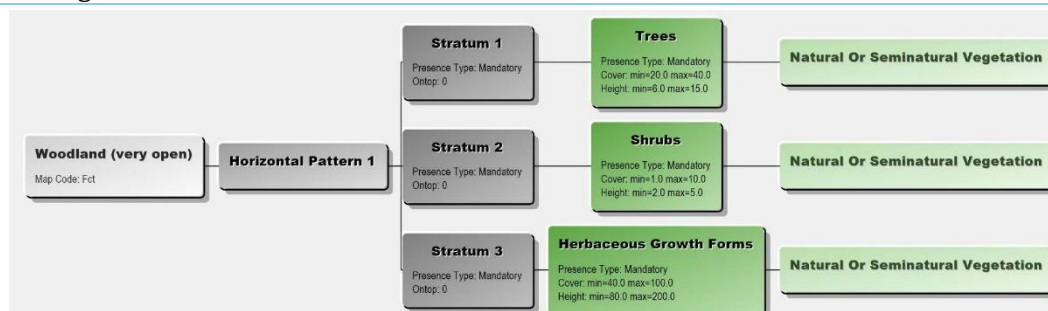
An extra strata of basic element shrub with the following attributes:

- Cover expressed in meters ranging from 1 to 10 percent.
- Height expressed in meters ranging from 2 to 5 meters.
- Vegetation artificiality defined as natural.

An extra strata of basic element herb with the following attributes:

- Cover expressed in meters ranging from 40 to 100 percent.
- Height expressed in meters ranging from 80 to 200 meters.
- Vegetation artificiality defined as natural.

LCCS diagram



Class expansion for tree dominated area

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element tree.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Leaf type:** specific leaf type for each growth form can be added.
- **Adding different strata of growth forms:** in addition to the main stratas characterizing this class other strata with different growth, forms can be added.

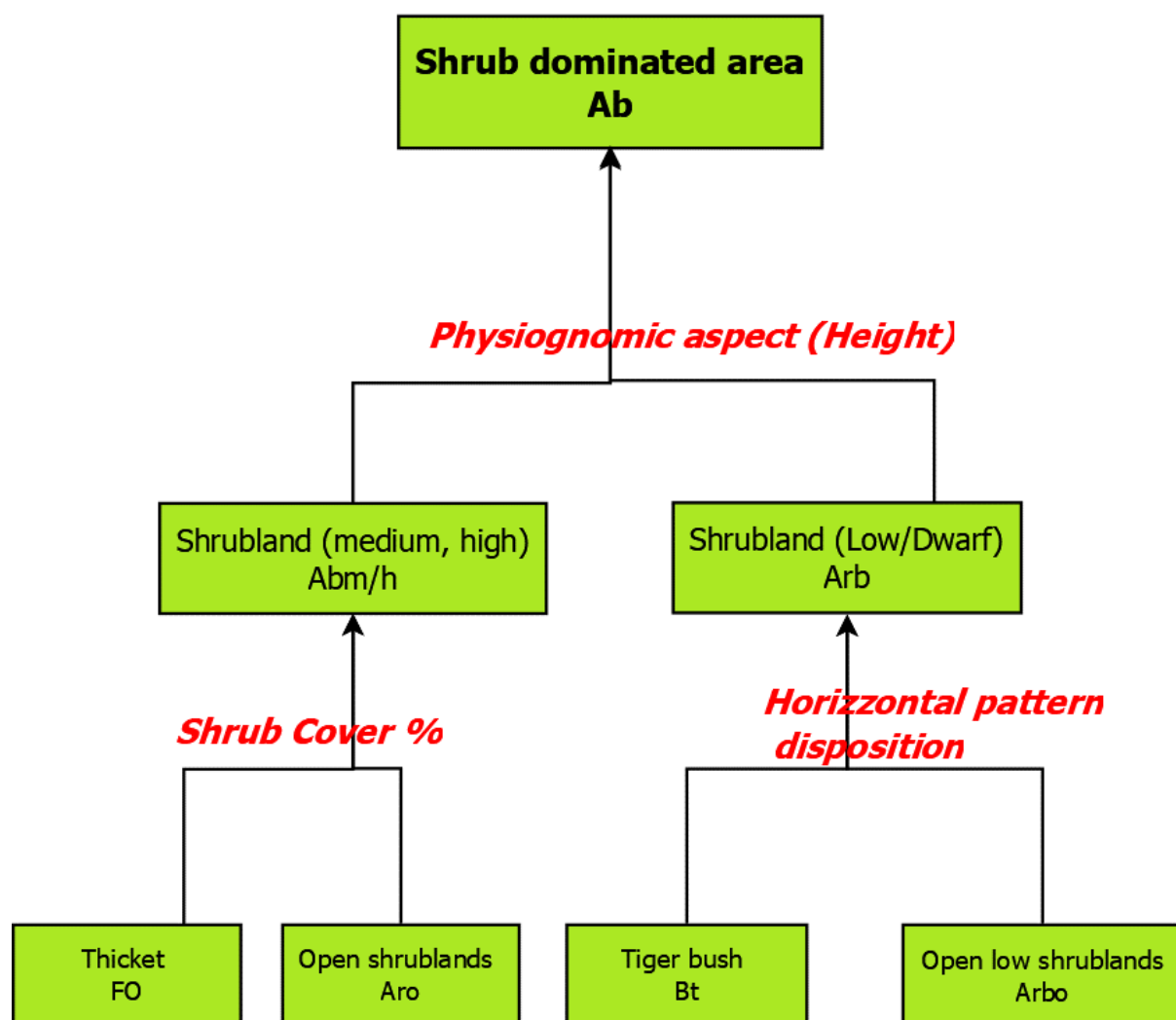
Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Growth from illness:** intended as the percent of trees damaged and the illness type.
- **Burnt status:** intended as the percent of trees burnt over the total.
- **Tree area management practices:** intended as types of forest management undertaken in a certain forest are.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Shrub dominated area - Ab

It corresponds to areas with natural semi-natural vegetation where the growth form shrub is dominant. The cover percentage of the element shrub is greater than 20 percent that is cover ranging from 20 to 100 percent. The presence of other woody (shrubs) or non woody (herbs) growth forms is recognized with any cover percentage.

Figure 14. Structure of shrub dominated areas



Derived classes (first level)

Two derived classes are foreseen classified as shrubland (medium, high) and shrubland (low/dwarf), sub-divided according to the different cover ranges that characterize the dominant element shrub.

Shrubland - medium, high (Abm/h)

This class is constituted mainly by shrubs with a coverage of about 20 to 100 percent. Vegetation height varies between 2m and 5m.

Shrubland - low/dwarf (Arb)

This class is constituted mainly by shrubs with a coverage of about 20 to 100 percent. Vegetation height varies between 0.2m and 2m.

Derived classes (second level)

A further sub-division is made both for the shrublands. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Thicket - FO

Picture

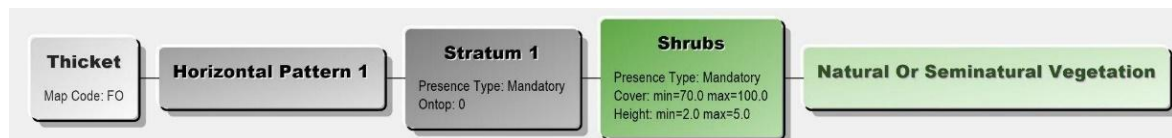


Description

This class describes the generic aspect of a thicket. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrubs.

- Cover expressed in percent of plants covering the ground ranging from 70 to 100 percent.
- Height expressed in meters ranging from 2 to 5 meters.
- vegetation artificiality in this case defined as natural.

LCCS diagram



Open shrublands - Aro

Picture

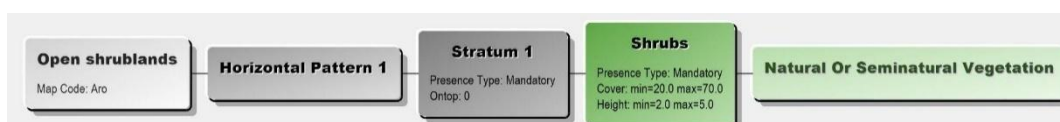


Description

This class describes the generic aspect of an open shrublands. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrubs.

- Cover expressed in percent of plants covering the ground ranging from 20 to 70 percent.
- Height expressed in meters ranging from 2 to 5 meters.
- vegetation artificiality in this case defined as natural.

LCCS diagram



Tiger bush - Bt

Picture



Description

This class describes the generic aspect of a tiger bush. It is constituted by two mandatory horizontal pattern and one basic stratum that defines the overall class structure. In first horizontal pattern (cover: 40-70 percent) the strata are constituted by one basic element shrubs.

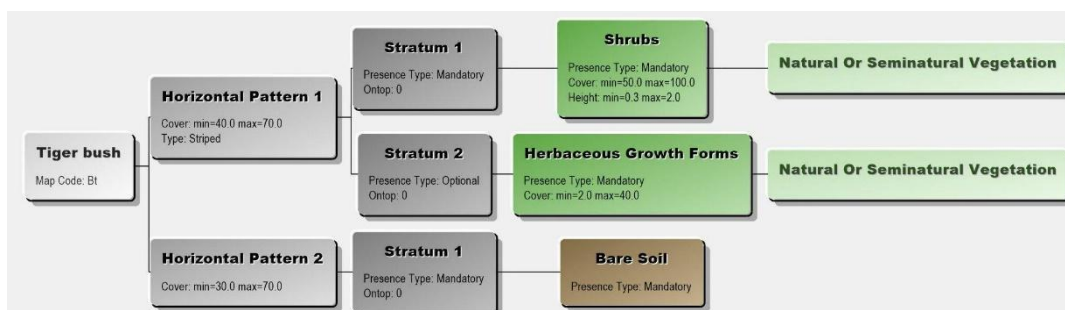
- Cover expressed in percent of plants covering the ground ranging from 50 to 100 percent.
- Height expressed in meters ranging from 0.3 to 2 meters.
- vegetation artificiality in this case defined as natural.

An extra strata of basic element herb with the following attributes:

- Cover expressed in meters ranging from 2 to 40 percent.
- Vegetation artificiality defined as natural.

In second horizontal pattern (cover: 30 – 70 percent), one basic mandatory stratum has a presence of bare soil.

LCCS diagram



Open low shrublands – Arbo

Picture

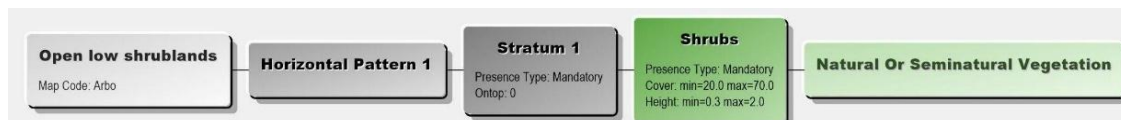


Description

This class describes the generic aspect of an open low shrublands. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrubs.

- Cover expressed in percent of plants covering the ground ranging from 20 to 70 percent.
- Height expressed in meters ranging from 0.3 to 2.0 meters.
- vegetation artificiality in this case defined as natural.

LCCS diagram



Class expansion for shrub dominated area

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element shrub.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Leaf type:** specific leaf type for each growth form can be added.
- **Adding different strata of growth forms:** in addition to the main strata characterizing this class other strata with different growth, forms can be added.

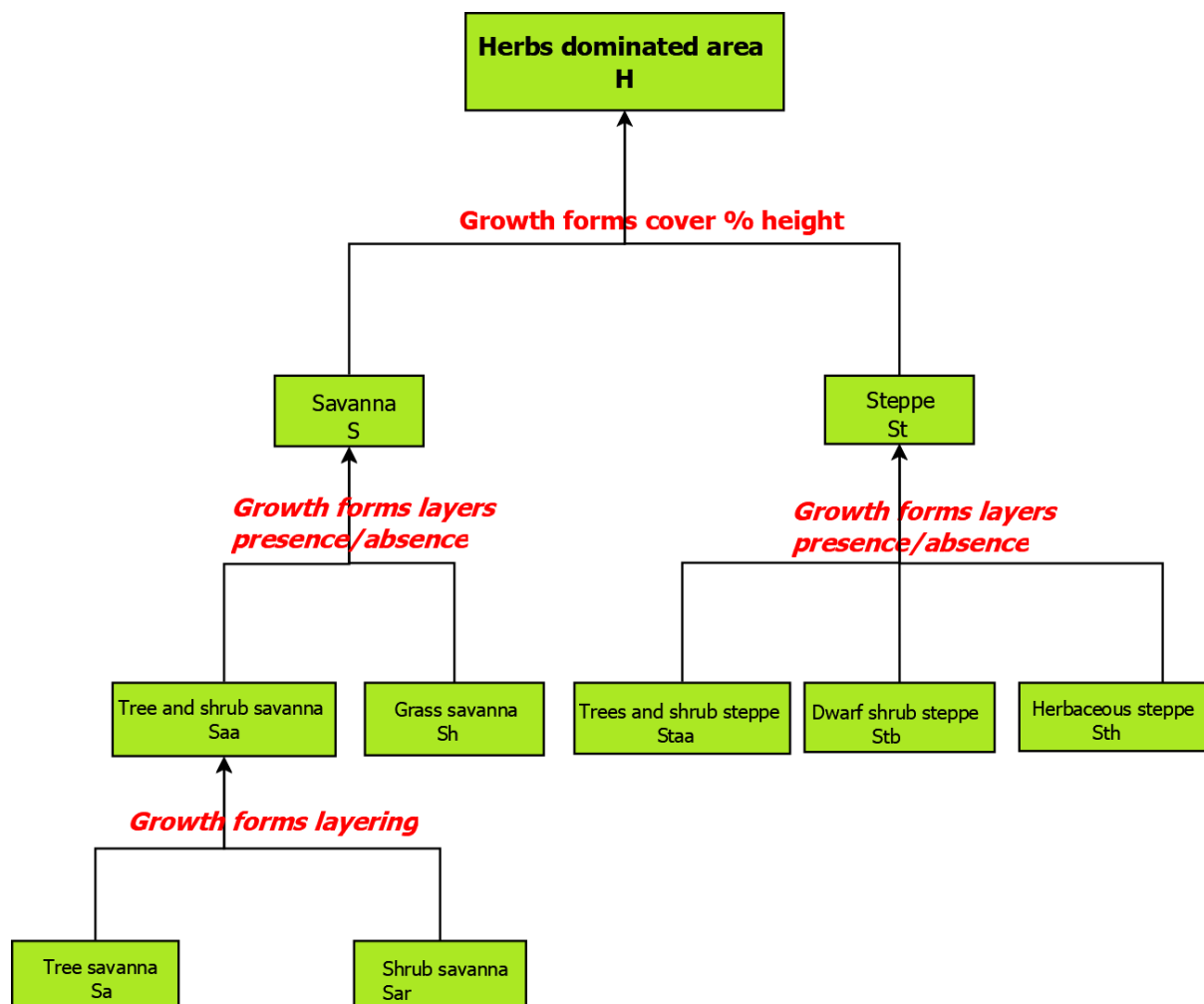
Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Burnt status:** intended as the percent of shrubs burnt over the total.
- **Grazing:** percentage of the intensity of grazing can be added for shrubs.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Herbs dominated area – H

This level corresponds to an area of natural vegetation with the mandatory presence of herbs. Herbaceous growth covers 20 – 100 percentage of the landscape. The structure of herbs dominated area is provided in Figure 15.

Figure 15. Structure of herbs dominated areas



Derived classes (first level)

Two derived classes are foreseen classified as savanna and steppe, sub-divided according to the different cover ranges that characterize the dominant element herbs.

Savanna (S)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class aspect. The strata are constituted by one basic element herb. The element herb has two attributes:

- Cover expressed in percent of the plant covering the ground ranging from 40 to 100 percent.
- Height expressed in centimeters ranging from 80 cm to 300 cm.
- Vegetation artificiality in this case is defined as natural.

Steppe (St)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class aspect. The strata are constituted by one basic element herb. The element herb has two attributes:

- Cover expressed in percent of the plant covering the ground ranging from 20 to 50 percent.
- Height expressed in centimetres ranging from 10 to 80 centimetres.
- Vegetation artificiality in this case is defined as natural.

Derived classes (second level)

A further sub-division is made both for the savanna and steppe. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Tree and shrub savanna - Saa

Picture



Description

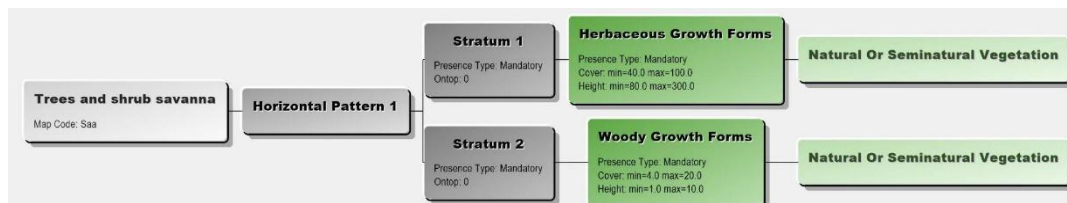
This class describes the generic aspect of tree and shrub savanna. It is constituted by two mandatory stratum that defines the overall class structure. First strata are constituted by one basic element herbaceous growth forms. The element herb has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 40 to 100 percent.
- Height expressed in meters ranging from 80 to 300 centimetres.
- vegetation artificiality in this case defined as natural.

Second strata of basic element woody growth forms are present with the following attributes:

- Cover expressed in percent ranging from 4 to 20 percent.
- Height expressed in meters ranging from 1cm to 10 cm.
- Vegetation artificiality defined as natural.

LCCS diagram



Tree savanna - Sa

Picture



Description

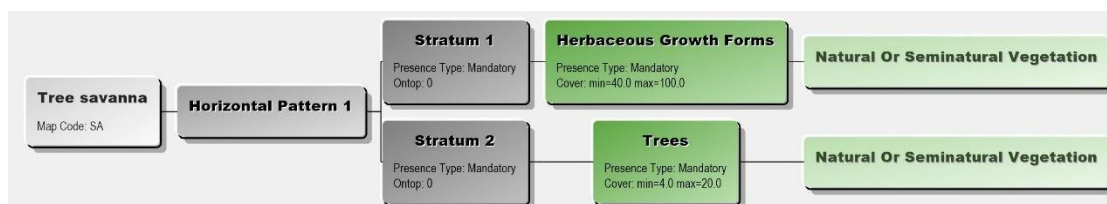
This class describes the generic aspect of tree savanna. It is constituted by one mandatory horizontal pattern that defines the overall class structure. The strata are constituted by one basic element herbaceous growth forms. The element herb has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 40 to 100 percent.
- vegetation artificiality in this case defined as natural.

A strata of basic element trees emergent from the main strata is present with the following attributes:

- Cover expressed in percent ranging from 4 to 20 percent.
- Vegetation artificiality defined as natural.

LCCS diagram



Shrub savanna – Sar

Picture



Description

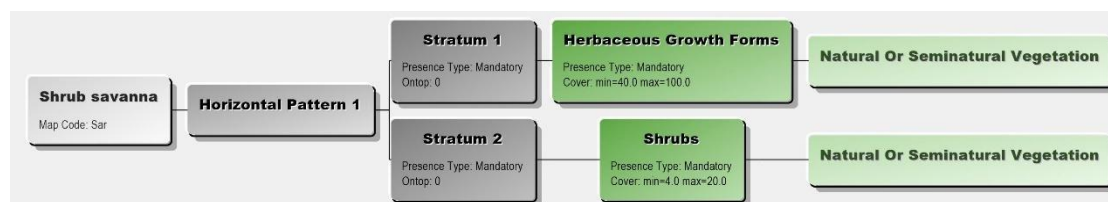
This class describes the generic aspect of shrub savanna. It is constituted by one mandatory horizontal pattern that defines the overall class structure. The strata are constituted by one basic element herbaceous growth forms. The element herb has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 40 to 100 percentage.
- vegetation artificiality in this case defined as natural.

A strata of basic element shrubs emergent from the main strata is present with the following attributes:

- Cover expressed in percent ranging from 4 to 20 percentage.
- Vegetation artificiality defined as natural.

LCCS diagram



Grass savanna – Sh

Picture



Description

This class describes the generic aspect of grass savanna. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element herbaceous growth forms. The element herb has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 40 to 100 percent.
- Height expressed in meters ranging from 80 to 300 centimetres.
- vegetation artificiality in this case defined as natural.

A strata of basic element woody growth forms emergent from the main strata is present with the following attributes:

- Cover expressed in percent ranging from 1 to 4 percent.
- Vegetation artificiality defined as natural.

LCCS diagram



Trees and shrub steppe – Staa

Picture



Description

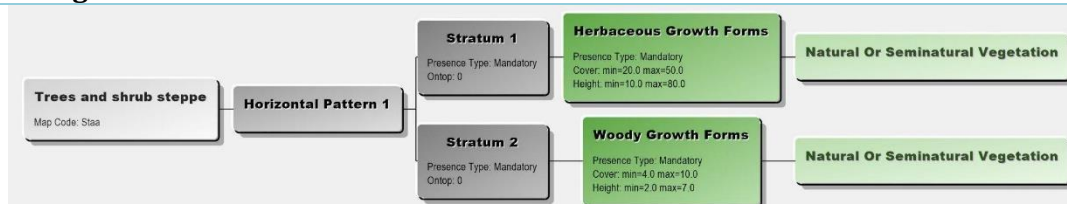
This class describes the generic aspect of tree and shrub steppe. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element herbaceous growth forms. The element herb has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 50 percent.
- Height expressed in meters ranging from 10 to 80 centimetres.
- vegetation artificiality in this case defined as natural.

A strata of basic element woody growth forms emergent from the main strata is present with the following attributes:

- Cover expressed in percent ranging from 4 to 10 percent.
- Height expressed in meters ranging from 2 to 7 meters.
- Vegetation artificiality defined as natural.

LCCS diagram



Dwarf shrub steppe – Stb

Picture



Description

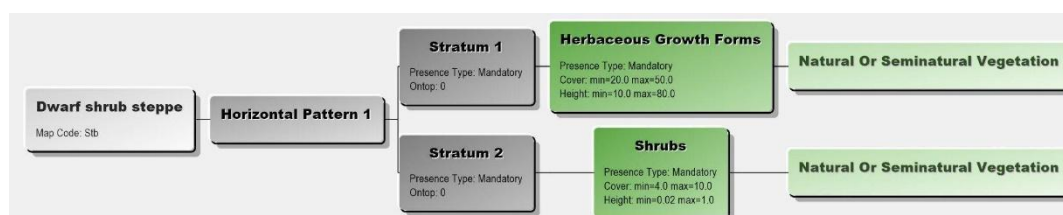
This class describes the generic aspect of dwarf shrub steppe. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element herbaceous growth forms. The element herb has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 50 percent.
- Height expressed in meters ranging from 10 to 80 centimetres.
- vegetation artificiality in this case defined as natural.

A stratum of basic element of shrubs emergent from the main strata is present with the following attributes:

- Cover expressed in percent ranging from 4 to 10 percent.
- Height expressed in meters ranging from 0.02 to 1 meter.
- Vegetation artificiality defined as natural.

LCCS diagram



Herbaceous steppe - Sth

Picture

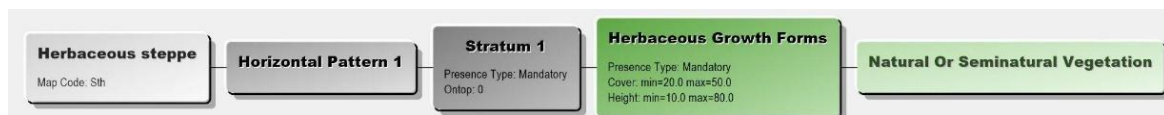


Description

This class describes the generic aspect of herbaceous steppe. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element herbaceous growth forms. The element herb has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 50 percent.
- Height expressed in meters ranging from 10 to 80 centimetres.
- vegetation artificiality in this case defined as natural.

LCCS diagram



Class expansion for herbaceous dominated area

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element herb.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Adding different strata of growth forms:** in addition to the main stratas characterizing this class other strata with different growth, forms can be added.

Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Burnt status:** intended as the percent of herbs burnt over the total.
- **Grazing:** percentage of the intensity of grazing can be added for herbs.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

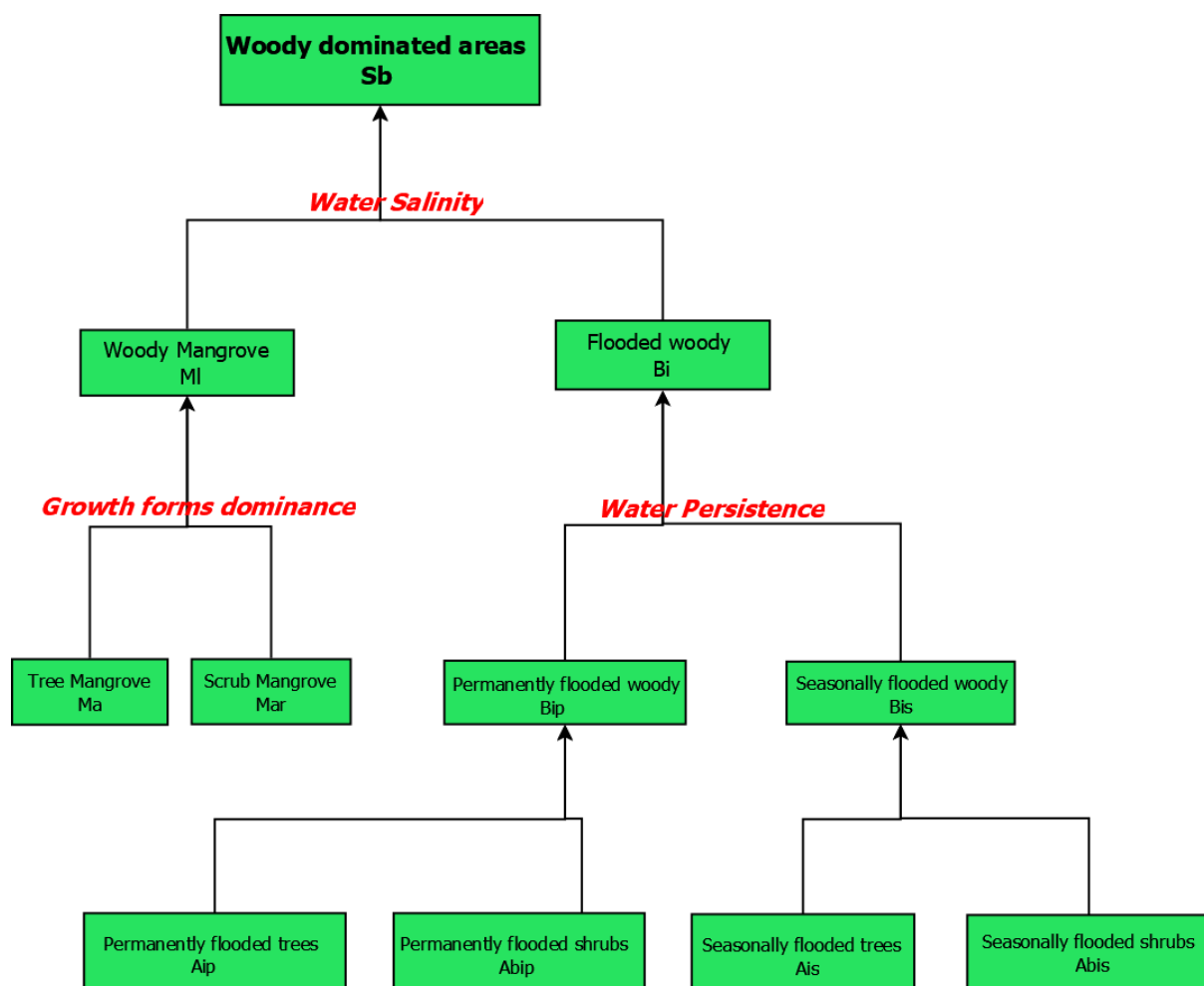
Section II

Natural semi-natural vegetation (aquatic or regularly flooded) - Vnar

Woody dominated area – Sb

It corresponds to areas with natural semi-natural vegetation where the growth form woody is dominant. The cover % of the element woody is greater than 20 percent (>20%) that is cover ranging from 20 to 100%. The presence of non-vegetated area that is water body is recognized in this area.

Figure 16. Structure of woody dominated areas



Derived classes (first level)

Two derived classes are foreseen classified as woody mangrove and flooded woody, sub-divided according to the different cover ranges that characterize the dominant element woody.

Woody mangrove (Ml)

This class is very basic, and generic being constituted by two mandatory stratum that defines the overall class structure. The strata are constituted by two basic elements that is woody and water body. The element woody has two attributes:

- Cover expressed in percent of plant covering the ground ranging from 20 - 100 percent.
- Vegetation artificiality in this case is defined as natural vegetation.

The element water body has two attributes:

- Periodic type is tidal
- Artificiality of water body is natural.
- Water salinity is brackish.

Flooded woody (Bi)

This class is very basic, and generic being constituted by two mandatory stratum that defines the overall class structure. The strata are constituted by two basic elements that is woody and water body. The element woody has two attributes:

- Cover expressed in percent of plant covering the ground ranging from 20 - 100 percent.
- Vegetation artificiality in this case is defined as natural vegetation.

The element water body has two attributes:

- Artificiality of water body is natural.
- Water salinity is fresh.

Derived classes (second level)

A further sub-division is made both for the closed and open tree formation. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Tree mangrove - Ma

Picture



Description

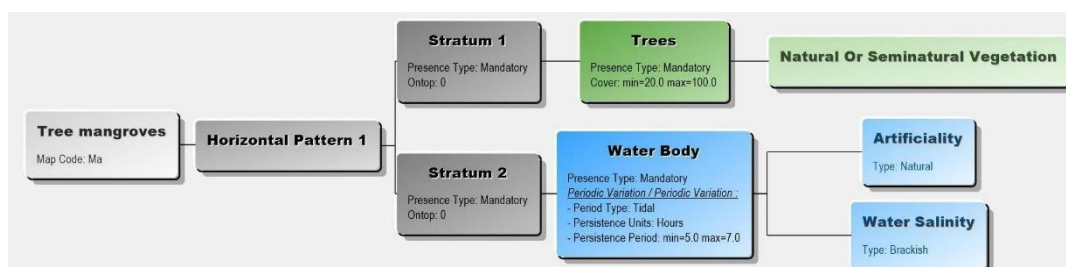
This class describes the generic aspect of a so-called tree mangrove. It is constituted by two mandatory stratum that defines the overall class structure. The strata are constituted by two basic elements tree and water body. The element tree has three attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percent.
- vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attributes:

- Periodic type is tidal.
- Artificiality of water body is natural.
- Water salinity is brackish.

LCCS diagram



Shrub mangrove - Mar

Picture



Description

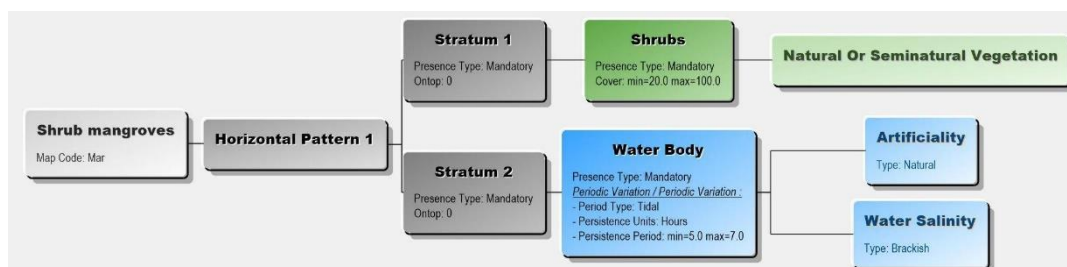
This class describes the generic aspect of a so-called shrub mangrove. It is constituted by two mandatory stratum that defines the overall class structure. The strata are constituted by two basic elements shrub and water body. The element tree has two attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percent.
- vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attributes:

- Periodic type is tidal.
- Artificiality of water body is natural.
- Water salinity is brackish.

LCCS diagram



Permanently flooded woody - Bip

Picture



Description

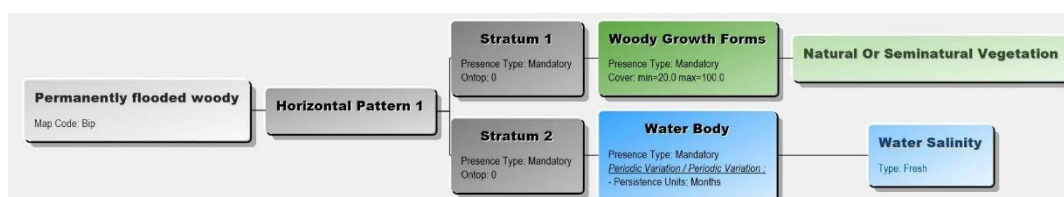
This class describes the generic aspect of permanently flooded woody. It is constituted by two mandatory stratum that defines the overall class structure. The strata are constituted by two basic elements woody growth form and water body. The element tree has two attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percent.
- vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attribute:

- Water salinity is fresh.

LCCS diagram



Permanently flooded trees - Aip

Picture



Description

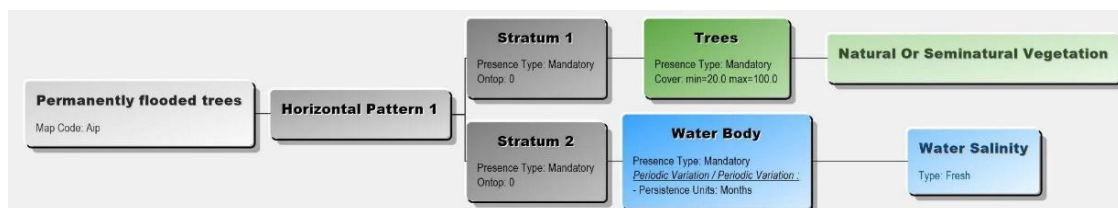
This class describes the generic aspect of permanently flooded trees. It is constituted by two mandatory stratum that defines the overall class structure. The strata are constituted by two basic elements trees and water body. The element tree has two attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percent.
- vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attribute:

- Water salinity is fresh.

LCCS diagram



Permanently flooded shrubs - Abip

Picture



Description

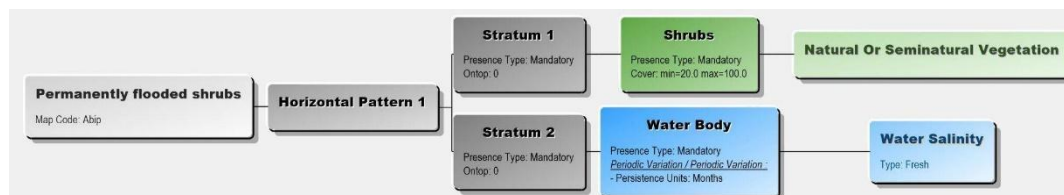
This class describes the generic aspect of permanently flooded shrubs. It is constituted by two mandatory stratum that defines the overall class structure. The strata are constituted by two basic elements shrubs and water body. The element tree has two attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percent.
- vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attribute:

- Water salinity is fresh.

LCCS diagram



Seasonally flooded woody - Bis

Picture



Description

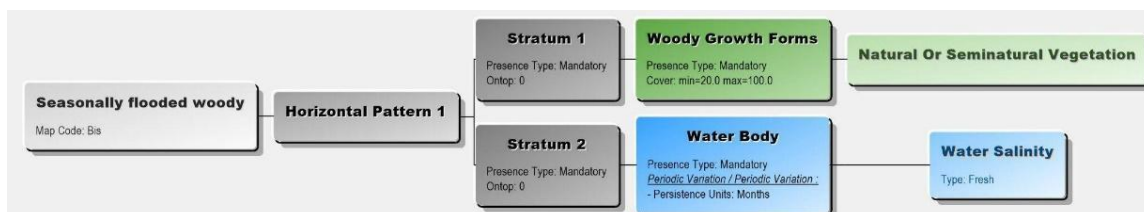
This class describes the generic aspect of the so-called seasonally flooded woody. Two mandatory strata define the overall class structure of the class. The strata are constituted by two basic elements: woody growth forms and water body. The element woody has two attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percent.
- Vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attribute:

- Water salinity is fresh.

LCCS diagram



Seasonally flooded trees - Ais

Picture



Description

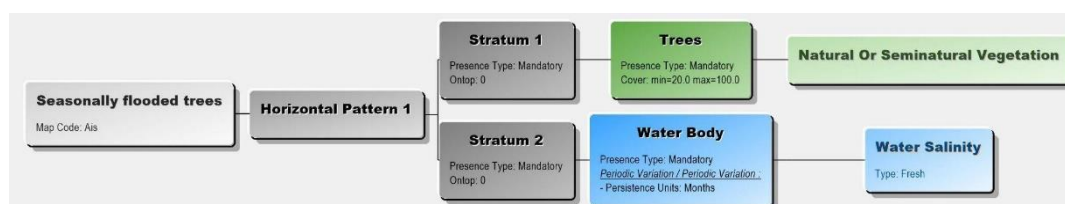
This class describes the generic aspects of the class referred to as the seasonally flooded trees. The strata are constituted by two basic elements: trees and water body. The element trees have two attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percent.
- Vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attribute:

- Water salinity is fresh.

LCCS diagram



Seasonally flooded shrubs - Abis

Picture



Description

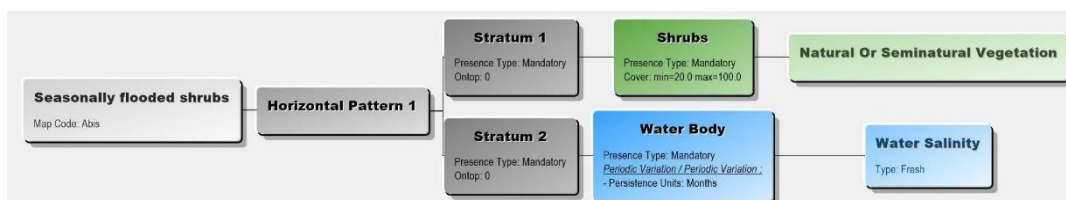
This class describes the generic aspects of the class referred to as the seasonally flooded shrubs. The strata are constituted by two basic elements: shrubs and water body. The element shrub has two attributes:

- Cover expressed in percent of plants covering the ground ranging from 20 to 100 percentage.
- vegetation artificiality in this case defined as natural.

A strata of basic element water body is present with the following attribute:

- Water salinity is fresh.

LCCS diagram



Class expansion for woody dominated area

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element tree.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Leaf type:** specific leaf type for each growth form can be added.
- **Adding different strata of growth forms:** in addition to the main stratas characterizing this class other strata with different growth, forms can be added.
- **Water body:** Water artificiality and salinity type can be further added.
- **Water periodic variation:** Period type and persistence period can be added.

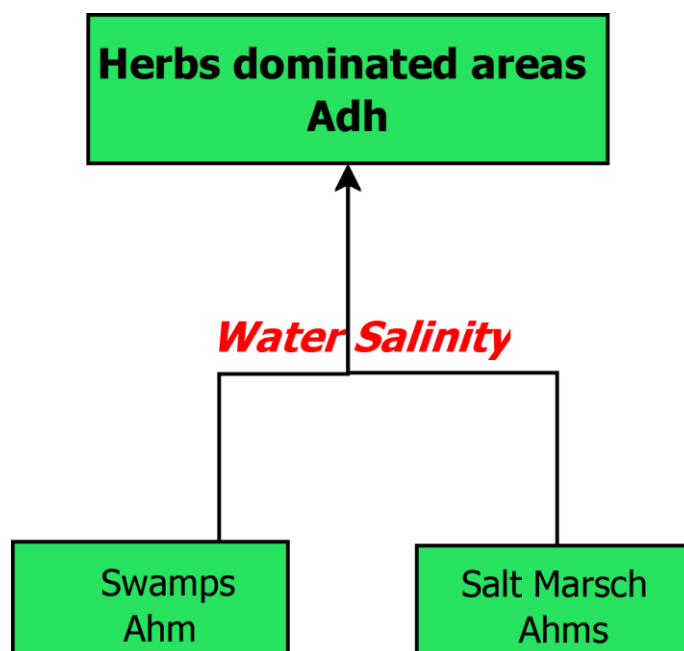
Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Growth from illness:** intended as the percent of trees damaged and the illness type.
- **Tree area management practices:** intended as types of forest management undertaken in a certain forest are.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Herbs dominated area – Adh

This level corresponds to an area of natural vegetation with the mandatory presence of herbs and water body. Herbaceous growth covers 20 – 100 percent of the landscape. The structure of herb dominated area can be seen in Figure 17.

Figure 17. Structure of herbs dominated areas



Derived classes (first level)

Two derived classes are foreseen classified as swamps and salt marsh, sub-divided according to the different cover ranges that characterize the dominant element herbs and water body.

Swamps (Ahm)

This class is very basic, and generic being constituted by two mandatory stratum that defines the overall class structure that is herbaceous growth form and water body. The element herbs have two attributes:

- Cover expressed in percent of plant covering the ground ranging from 20 - 100 percent.
- Vegetation artificiality in this case is defined as natural vegetation.

The element water body has two attributes:

- Artificiality of water body is natural.

- Water salinity is fresh.

Salt marsh (Ahms)

This class is very basic, and generic being constituted by two mandatory stratum that defines the overall class structure that is herbaceous growth form and water body. The element herbs have two attributes:

- Cover expressed in percent of plant covering the ground ranging from 20 - 100 percent.
- Vegetation artificiality in this case is defined as natural vegetation.

The element water body has two attributes:

- Artificiality of water body is natural.
- Water salinity is brackish.

Derived classes (second level)

A further sub-division is made both for the closed and open tree formation. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for herbs dominated area

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element herb.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Adding different strata of growth forms:** in addition to the main stratas characterizing this class other strata with different growth, forms can be added.
- **Water body:** Water artificiality and salinity type can be further added.
- **Water periodic variation:** Period type and persistence period can be added.

Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Grazing:** percentage of the intensity of grazing can be added for herbs.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

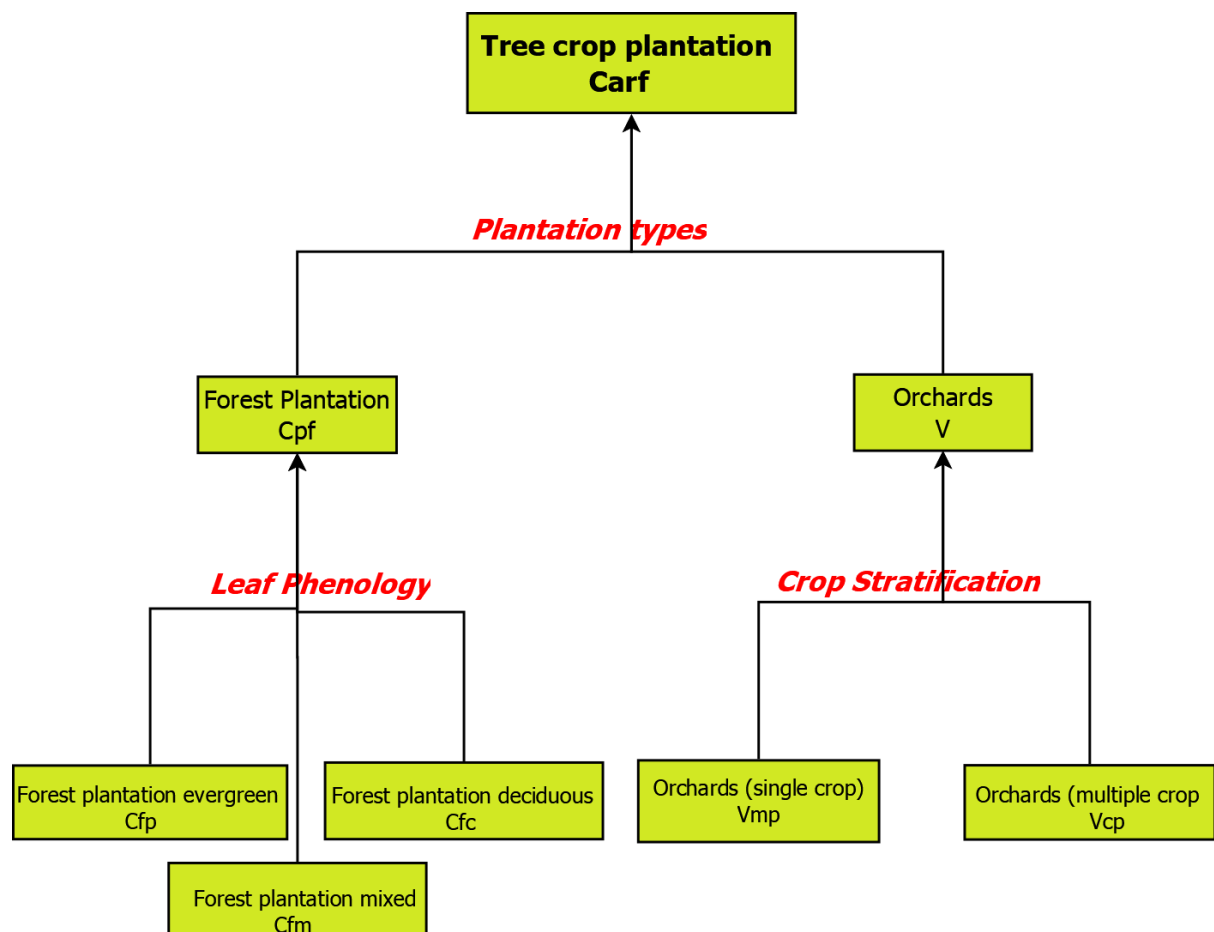
Section III

Cultivated rainfed - Cp

Tree crop plantation – Carf

It corresponds to areas with cultivated rainfed agriculture where the growth form tree is dominant. The structure of the tree crop plantation can be seen Figure 18.

Figure 18. Structure of tree crop plantation



Derived classes (first level)

Two derived classes are foreseen classified as forest plantation and orchards, sub-divided according to the different plantation types that characterize the dominant element tree.

Forest plantation (Cpf)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element tree. The element tree has three attributes:

- Height of the planted trees varies depending on the plantation type.
- It is rainfed forest plantation area.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Orchards (V)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class aspect. The strata are constituted by one basic element tree. The element tree has two attributes:

- Height of the planted trees varies depending on the plantation type.
- It is rainfed orchard and other plantation area.
- Vegetation artificiality in this case is defined as cultivated vegetation.

An extra strata of basic element herbaceous growth forms with the following attribute:

- Vegetation artificiality in this case is defined as cultivated vegetation.

Derived classes (second level)

A further sub-division is made both for the forest plantation and orchards. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Forest plantation evergreen - Cfp

Picture



Description

This class describes the generic aspect of the evergreen forest plantation. It is composed of a single mandatory stratum that defines the overall structure of the class. The element tree in this class has the following attributes:

- Height of the planted trees varies depending on the plantation type.
- It is rainfed forest plantation area.
- Vegetation artificiality in this case is defined as cultivated vegetation.

LCCS diagram



Forest plantation mixed – Cfm

Picture

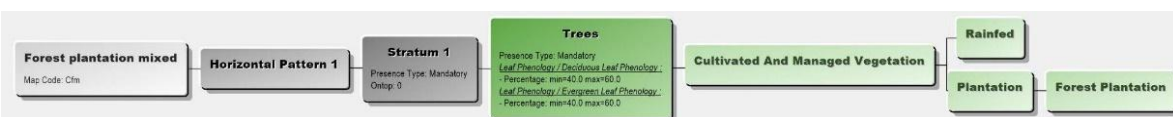


Description

This class describes the generic aspect of the mixed forest plantation. It is composed of a single mandatory stratum that defines the overall structure of the class. The element tree in this class has the following attributes:

- Height of the planted trees varies depending on the plantation type.
- It is rainfed forest plantation area.
- Vegetation artificiality in this case is defined as cultivated vegetation.
- Deciduous and/or evergreen leaf phenology is 40 – 60 percent.

LCCS diagram



Forest plantation deciduous - Cfc

Picture



Description

This class describes the generic aspect of the deciduous forest plantation. It is composed of a single mandatory stratum that defines the overall structure of the class. The element tree in this class has the following attributes:

- Height of the planted trees varies depending on the plantation type.
- It is rainfed forest plantation area.
- Vegetation artificiality in this case is defined as cultivated vegetation.
- Deciduous leaf phenology is 40 – 60 percent.

LCCS diagram



Orchards (single crop) - Vmp

Picture



Description

This class describes the generic aspect of the single type of crop of orchards. It is composed of a single mandatory stratum that defines the overall structure of the class. The element tree in this class has the following attributes:

- Height of the planted trees varies depending on the plantation type.
- It is rainfed plantation area with single crop.
- Vegetation artificiality in this case is defined as cultivated vegetation.
- Plantation type is orchard and other plantation.

LCCS diagram



Orchards (multiple crop) - Vcp

Picture



Description

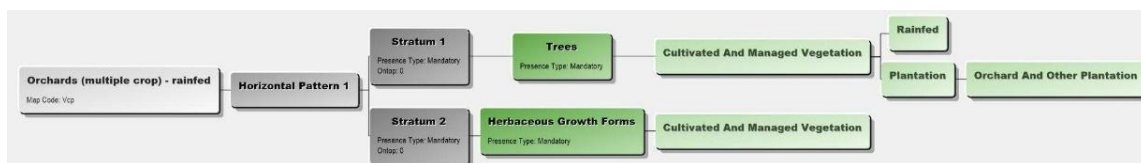
This class describes the generic aspect of the multiple type crops of orchards. It is composed of a single mandatory stratum that defines the overall structure of the class. The element tree in this class has the following attributes:

- Height of the planted trees varies depending on the plantation type.
- It is rainfed plantation area with multiple crops.
- Vegetation artificiality in this case is defined as cultivated vegetation.
- Plantation type is orchard and other plantation.

An extra element is herbaceous growth form with following attribute:

- Vegetation artificiality in this case is defined as cultivated vegetation.
- It is rainfed plantation area with multiple crops.
- Vegetation artificiality in this case is defined as cultivated vegetation.

LCCS diagram



Class expansion for tree crop plantation

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element tree.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Leaf type:** specific leaf type for each growth form can be added.
- **Adding different strata of growth forms:** in addition to the main strata characterizing this class other strata with different growth, forms can be added.

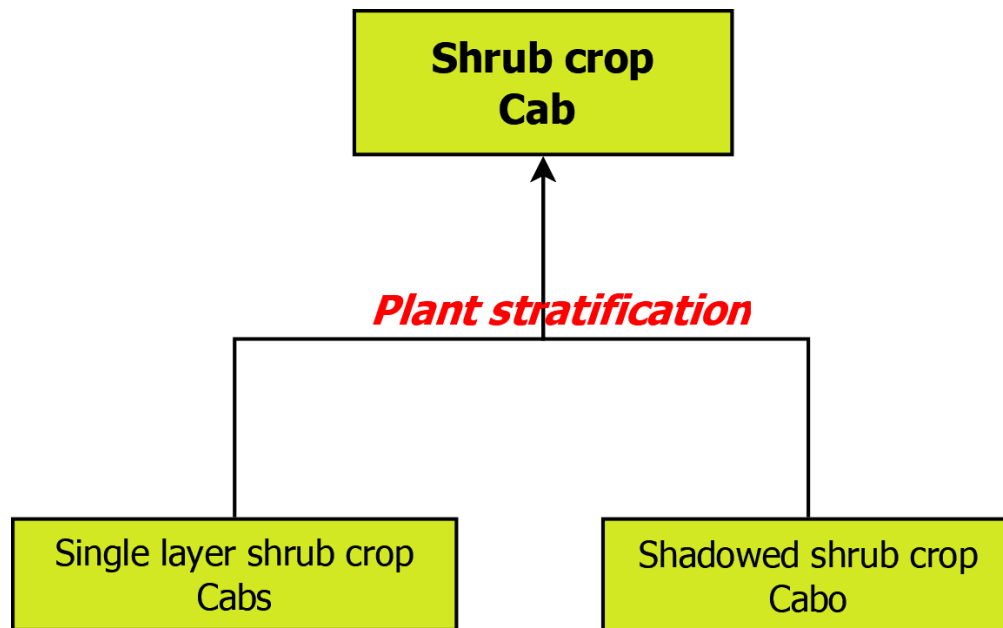
Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Field size:** intended as the field size for cultivated rainfed can be added.
- **Plant spreading geometry:** intended as geometry of the spreading plant can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Shrub crop – Cab

The shrub crop corresponds to areas with cultivated rainfed agriculture where the growth form shrub is dominant. Structure of shrub crop is provided in Figure 19.

Figure 19. Structure of Shrub crop



Derived classes (first level)

Two derived classes are foreseen classified as single layer shrub and shadowed shrub crop, subdivided according to the different plant stratification that characterize the dominant element plantation.

Single layer shrub crop (Cabs)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrub with the following attributes:

- Height of the plantation varies depending on the plantation type.
- It is rainfed plantation area with single shrub crop layer.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Shadowed crop (Cabo)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrub with the following attributes:

- Height of the plantation varies depending on the plantation type.
- It is rainfed plantation area with shadowed shrub crop layer.
- Vegetation artificiality in this case is defined as cultivated vegetation.

An extra strata of basic element tree is present with the following attribute:

- Height of the plantation varies depending on the plantation type.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Derived classes (second level)

A further sub-division is made both for the single layer shrub crop and shadowed crop. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for shrub crop

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element shrub.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Leaf type:** specific leaf type for each growth form can be added.
- **Adding different strata of growth forms:** in addition to the main strata characterizing this class other strata with different growth, forms can be added.

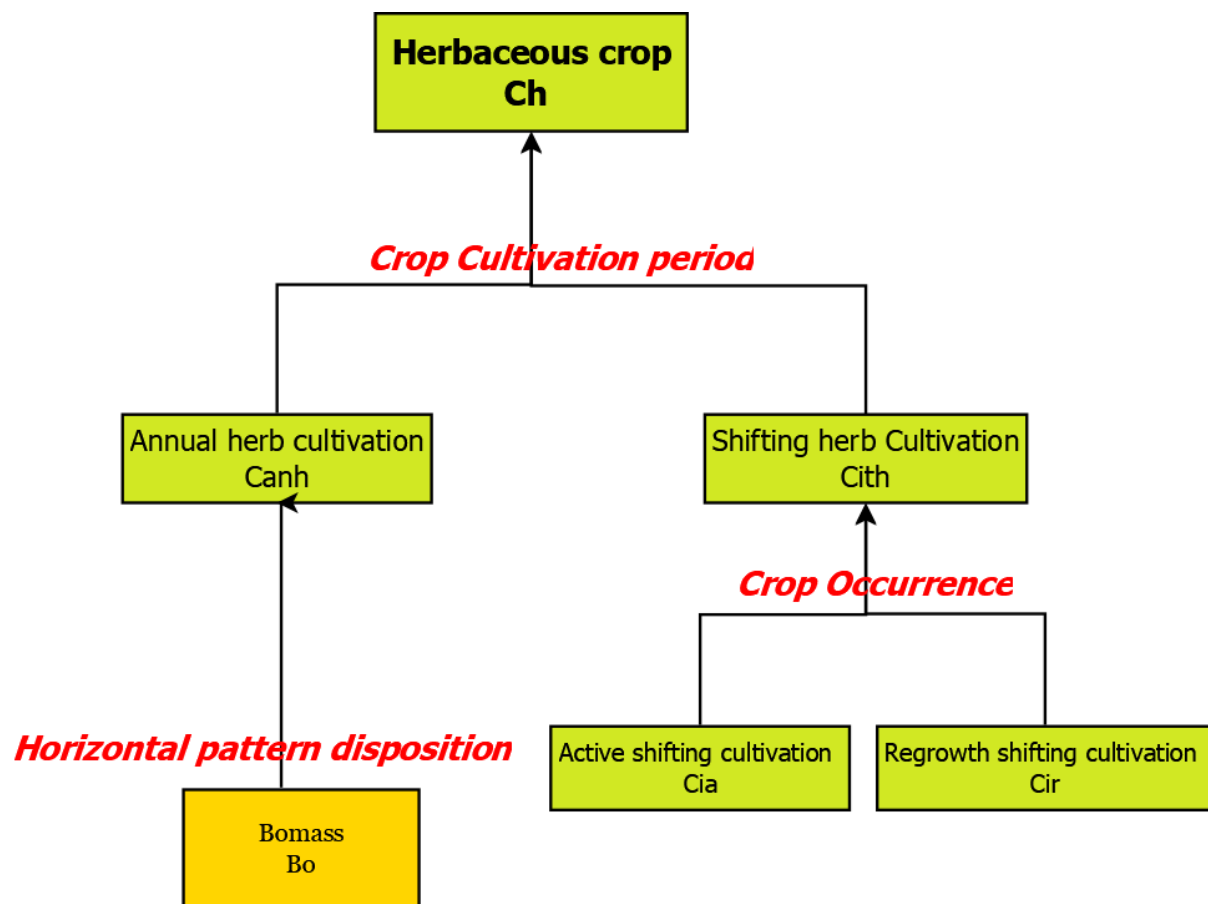
Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Field size:** intended as the field size for cultivated rainfed can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Herbaceous crop – Ch

Herbaceous crop corresponds to areas with cultivated rainfed agriculture where the growth form herb is dominant. The structure of herbaceous crop can be seen in Figure 20.

Figure 20. Structure of herbaceous crop



Derived classes (first level)

Two derived classes are foreseen classified as annual herb cultivation and shifting herb cultivation, sub-divided according to the different crop cultivation period that characterize the dominant element plantation.

Annual herb cultivation (Canh)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrub with the following attributes:

- It is rainfed plantation area with rotational period from 1 to 3 years.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Shifting herb cultivation (Cith)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrub with the following attributes:

- It is rainfed plantation area with rotational period from 1 to 2 years.
- Vegetation artificiality in this case is defined as cultivated vegetation.
- Cover percentage is 15 – 30 percent.

An extra basic stratum for herb growth form is present with following attributes:

- Vegetation artificiality in this case is defined as cultivated vegetation.
- Cover percentage is 30 – 85 percent.

Derived classes (second level)

A further sub-division is made both for annual herb cultivation and shifting herb cultivation. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Active shifting cultivation – Cia

Picture



Description

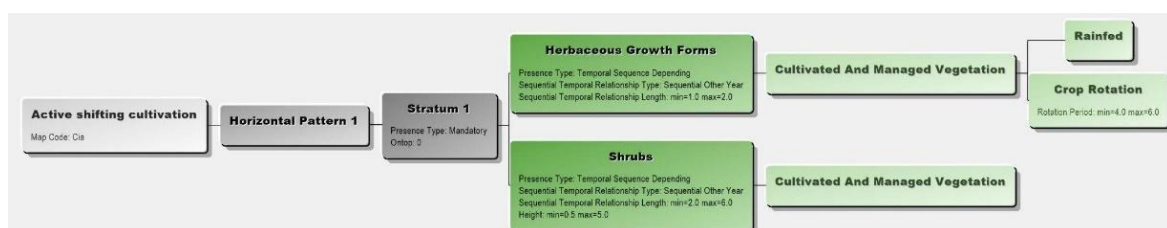
This class includes lands where herbaceous and/or shrub crops are cultivated temporarily. It is composed of a single mandatory stratum that defines the overall structure of the class. The element herb in this class has the following attributes:

- Rotational period is 4-6 years.
- Sequential temporal length is 1-2 years.
- It is rainfed plantation area.
- Vegetation artificiality in this case is defined as cultivated vegetation.

A basic element shrub is present in this class with following attributes:

- Sequential temporal length is 2-6 years.
- It is rainfed plantation area.
- Height of this element is 0.5 – 5.0 meters.
- Vegetation artificiality in this case is defined as cultivated vegetation.

LCCS diagram



Regrowth shifting cultivation - Cir

Picture



Description

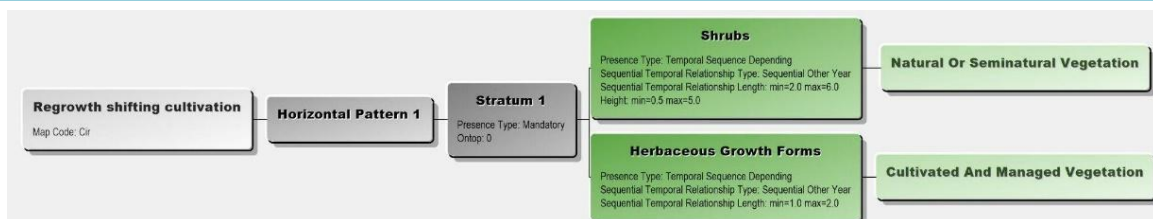
This class includes lands where herbaceous and/or shrub crops are cultivated temporarily, then abandoned and allowed to return to their natural vegetation while the farmer moves on to another area. It is composed of a single mandatory stratum that defines the overall structure of the class. The element shrub in this class has the following attributes:

- Sequential temporal length is 2-6 years.
- It is rainfed plantation area.
- Height of this element is 0.5 – 5.0 meters.
- Vegetation artificiality in this case is natural.

A basic element herb is present in this class with following attributes:

- Sequential temporal length is 1-2 years.
- It is rainfed plantation area.
- Vegetation artificiality in this case is defined as cultivated vegetation.

LCCS diagram



Class expansion for herbaceous crop

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons that is legend scope, terrain knowledge etc. wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element herb.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Adding different strata of growth forms:** in addition to the main strata characterizing this class other strata with different growth, forms can be added.

Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Seeding time:** information about month that crop was sown can be added
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

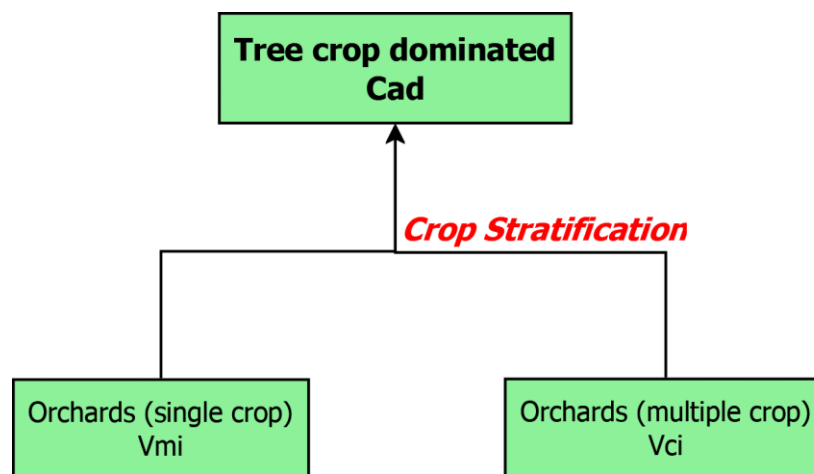
Section IV

Cultivated irrigated - Ci

Tree crop dominated – Cad

The tree dominated corresponds to areas with cultivated irrigated agriculture where the growth form tree is dominant. The structure of the tree crop dominated can be seen in Figure 21.

Figure 21. Structure of tree crop dominated



Derived classes (first level)

Two derived classes are foreseen classified as single crop orchard and multiple crop orchard, subdivided according to the different cover ranges that characterize the dominant element tree.

Orchards (single crop) (Vmi)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element tree with the following attributes:

- It is irrigated plantation area with single tree crop.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Orchards (multiple crop) (Vci)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element tree with the following attributes:

- It is irrigated plantation area with multiple tree crop.
- Multiple crops with rotational same year period from 3 to 6 years.
- Vegetation artificiality in this case is defined as cultivated vegetation.

An extra strata of basic element herbaceous growth forms with the following attribute:

- Vegetation artificiality in this case is defined as cultivated vegetation.

Derived classes (second level)

A further sub-division is made both for orchards single and multiple crops. At this level, the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for tree crop dominated

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element tree.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Leaf type:** specific leaf type for each growth form can be added.
- **Adding different strata of growth forms:** in addition to the main strata characterizing this class other strata with different growth, forms can be added.

Other attributes:

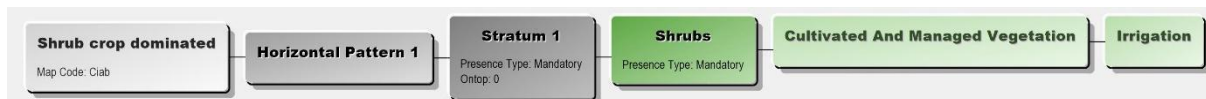
- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Field size:** intended as the field size for cultivated rainfed can be added.
- **Irrigation type and percentage:** Any of several means of providing an artificial regular supply of water, in addition to rain, to the crop(s) with percentage can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Shrub crop dominated – Ciab

It corresponds to areas with cultivated irrigated agriculture where the growth form shrub is dominant. The element shrub has following attributes:

- Height of the plantation varies depending on the plantation type.
- It is irrigated plantation area with shrub dominance.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Figure 22. LCCS diagram for shrub crop dominated



Derived classes

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for shrub crop dominated

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons that is legend scope, terrain knowledge etc. wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element shrub.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Leaf type:** specific leaf type for each growth form can be added.
- **Adding different strata of growth forms:** in addition to the main strata characterizing this class other strata with different growth, forms can be added.

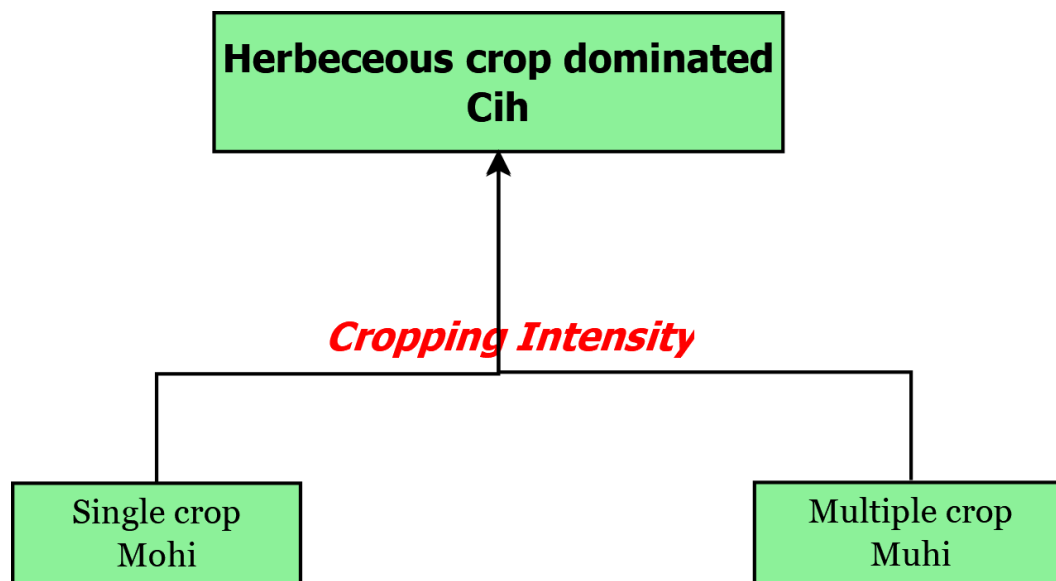
Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Field size:** intended as the field size for cultivated rainfed can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Herb crop plantation – Cih

It corresponds to areas with cultivated irrigated agriculture where the growth form herb is dominant. The structure of the herb crop plantation can be seen in Figure 23.

Figure 23. Structure of herb crop plantation



Derived classes (first level)

Two derived classes are foreseen classified as single crop and multiple crops, sub-divided according to the different cropping intensity that characterize the dominant element plantation.

Single crop - herbaceous irrigated (Mohi)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrub with the following attributes:

- It is irrigated plantation area with single herbaceous crop.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Multiple crop - herbaceous irrigated (Muhi)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element shrub with the following attributes:

- It is irrigated plantation area with multiple herbaceous crops.

- Multiple crops with rotational same year period from 3 to 6 years.
- Vegetation artificiality in this case is defined as cultivated vegetation.

Derived classes (second level)

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for herb crop dominated

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element herb.
- **Leaf phenology:** specific leaf phenology for each growth form can be defined.
- **Adding different strata of growth forms:** in addition to the main stratas characterizing this class other strata with different growth, forms can be added.

Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Irrigation type and percentage:** Any of several means of providing an artificial regular supply of water, in addition to rain, to the crop(s) with percentage can be added.
- **Seeding time:** information about month that crop was sown can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Section V

Cultivated post-flooded - Cd

Post-flooded herbaceous cultivation – Chai

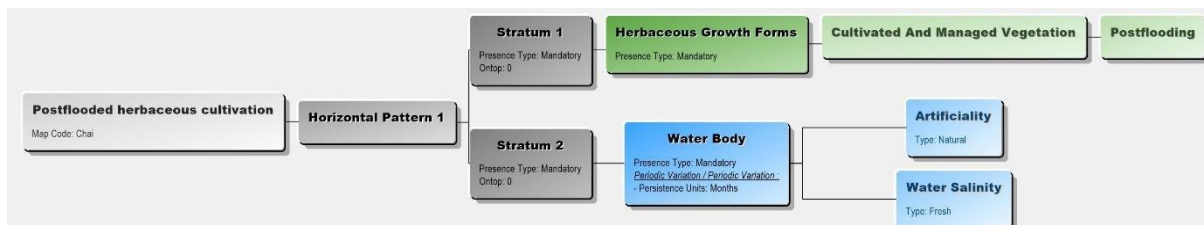
It corresponds to cultivated agriculture with flooded area where the growth form herb is dominant. The element herb has following attributes:

- Herbaceous crops are post-flooded.
- Vegetation artificiality in this case is defined as cultivated vegetation.

A basic element water has following attributes:

- Monthly periodic variation.
- Artificiality of water body is natural.
- Water salinity is fresh.

Figure 24. LCCS diagram for post flooded herbaceous cultivation



Derived classes

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for post flooded herbaceous cultivation

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Water body:** Water artificiality and salinity type can be further added.
- **Water periodic variation:** Period type and persistence period can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Flooded herbaceous cultivation – Chi

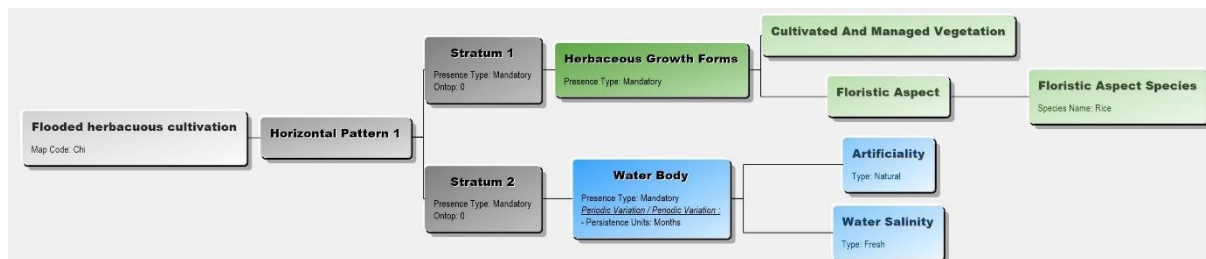
It corresponds to cultivated agriculture with flooded area where the growth form herb is dominant. The element herb has following attributes:

- Herbaceous crops are permanently flooded.
- Floristic aspect species: Rice.
- Vegetation artificiality in this case is defined as cultivated vegetation.

A basic element water has following attributes:

- Monthly periodic variation.
- Artificiality of water body is natural.
- Water salinity is fresh.

Figure 25. LCCS diagram for flooded herbaceous cultivation



Derived classes

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for flooded herbaceous cultivation

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Other attributes:

- **Floristic name:** intended as the floristic name of the plant species.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Water body:** Water artificiality and salinity type can be further added.
- **Water periodic variation:** Period type and persistence period can be added.
- **Water depth:** Water depth can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

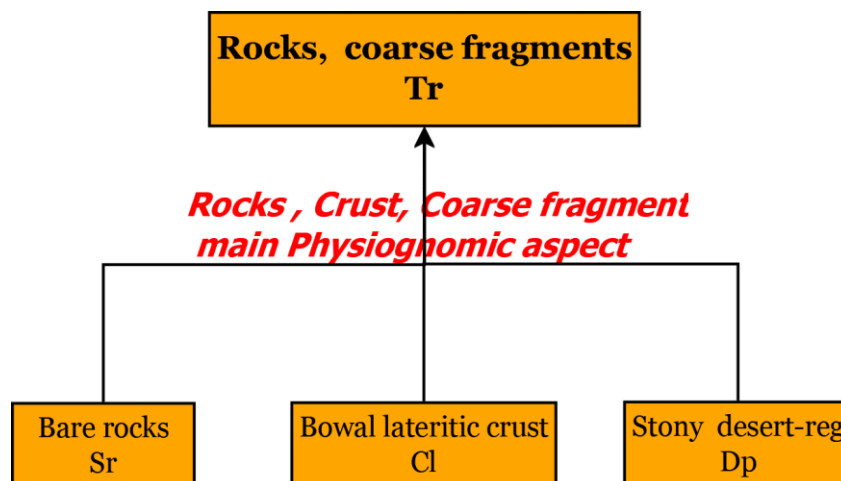
Section VI

Natural surfaces – Sn

Rocks, coarse fragments – Tr

It corresponds to areas with natural surfaces where the rocky and coarse fragments are dominant. The presence of sub-surfaces is recognized with main physiognomic aspect. The structure of the rocks, coarse fragments can be seen in Figure 26.

Figure 26. Structure of rocks, coarse fragments



Derived classes (first level)

Three derived classes are foreseen classified as bare rocks, bowal lateritic crust and stony desert.

Bare rocks (Sr)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element rock.

Bowel lateritic crust (Cl)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element hard pans with iron pan/laterite type.

Stony Desert – Reg (Dp)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element coarse fragment minerals.

Derived classes (second level)

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for rocks, coarse fragments

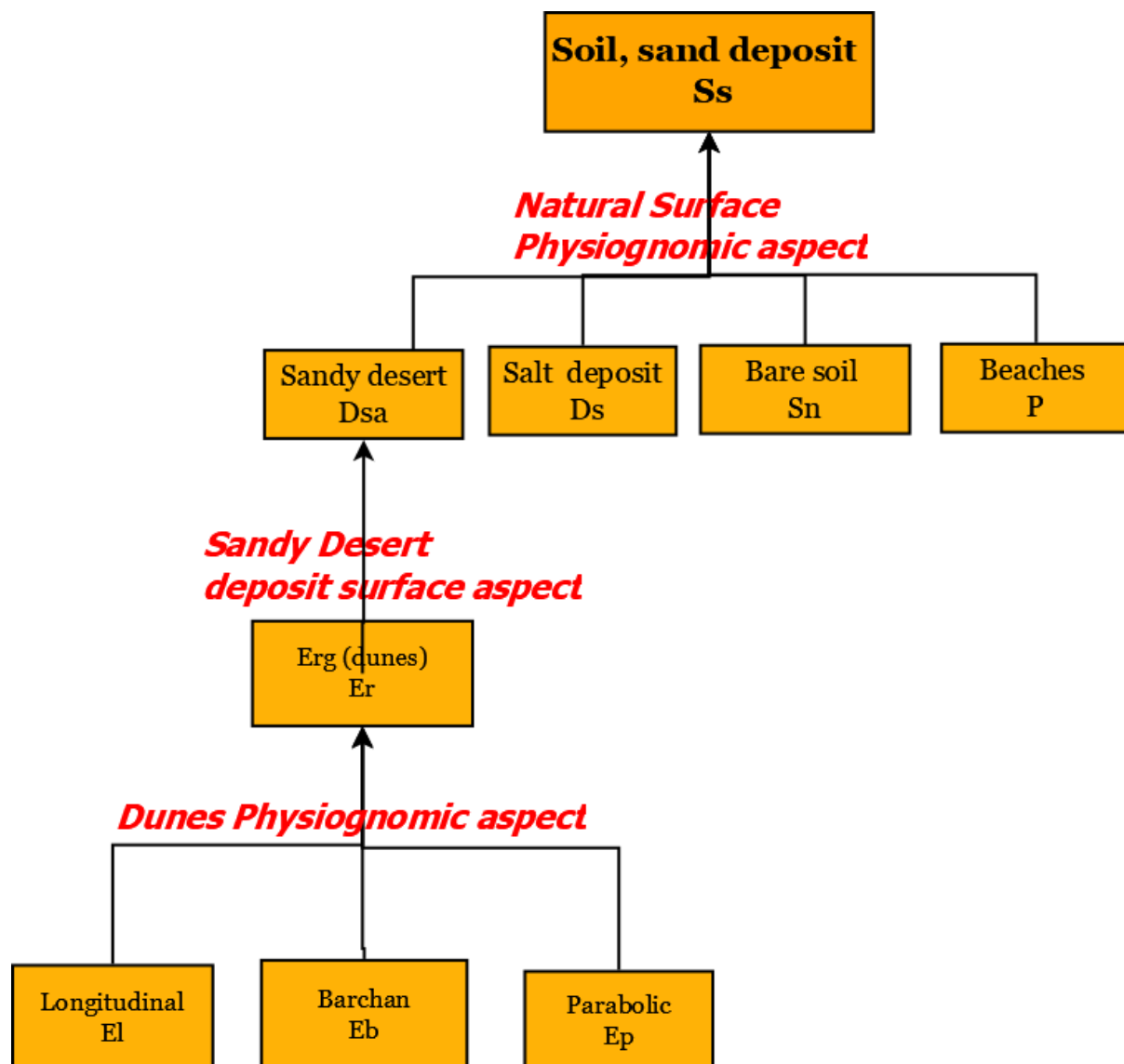
The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

- **Rock type:** rock type and rock age type for consolidated surface characteristics can be added.
- **Soil type:** soil type for unconsolidated surface characteristics can be added.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Soil sand deposit – Ss

It corresponds to areas with natural surfaces where the soil, sand and deposits are dominant. The presence of sub-surfaces is recognized with main physiognomic aspect. The structure of the soil sand deposit can be seen in Figure 27.

Figure 27. Structure of soil, sand deposit



Derived classes (first level)

Four derived classes are foreseen classified as sandy desert, salt deposit, bare soil, and beaches, sub-divided according to the different physiognomic aspect.

Sandy desert (Dsa)

This class is very basic, and generic being constituted by one mandatory stratum that defines overall class structure. The strata are constituted by one basic element loose and shifting sand.

Salt deposit (Ds)

This class is very basic, and generic being constituted by one mandatory stratum that defines overall class structure. The strata are constituted by one basic element inorganic deposit with salt flat type.

Bare soil (Sn)

This class is very basic, and generic being constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element bare soil.

Beaches (P)

This class is very basic, and generic being constituted by one mandatory stratum that defines overall class structure. The strata are constituted by one basic element loose and shifting sand.

Derived classes (second level)

A further sub-division is made both for sandy desert. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Erg (dunes) - Er

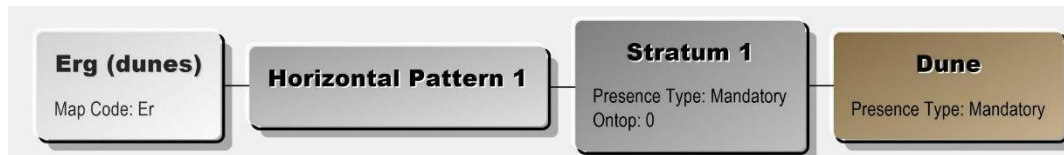
Picture



Description

This class describes the generic aspect of dunes. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element dune.

LCCS diagram



Er (dunes) longitudinal - El

Picture



Description

This class describes the generic aspect of dunes. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element dune with longitudinal type.

LCCS diagram



Er (dunes) barchan - Eb

Picture



Description

This class describes the generic aspect of dunes. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element dune with barchan type.

LCCS diagram



Er (dunes) parabolic - Ep

Picture



Description

This class describes the generic aspect of dunes. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by one basic element dune with parabolic type.

LCCS diagram



Class expansion for soil sand deposit

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

- **Rock type:** rock type and rock age type for consolidated surface characteristics can be added.
- **Soil type:** soil type for unconsolidated surface characteristics can be added.
- **Geographic location or altitude:** intended as any information related to a specific geographic location and or altitude ranges.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

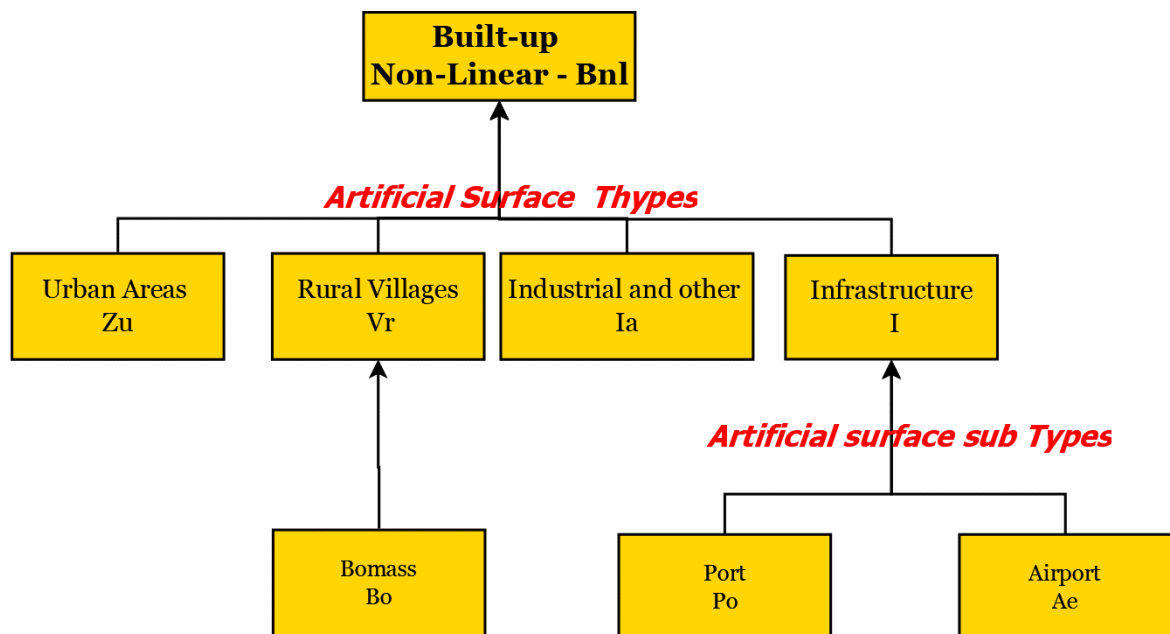
Section VII

Artificial surfaces – Sa

Built-up Nonlinear – BNI

It corresponds to artificial and impervious surface which are paved with hard materials are built-up non-linear. The presence of sub-surfaces is recognized with types of artificial surface.

Figure 28. Structure of built-up non-linear



Derived classes (first level)

Four derived classes are foreseen classified as urban area, rural villages, industrial and infrastructure, sub-divided according to the different artificial surface types.

Urban areas (Zu)

Artificial surfaces with urban area geographical aspect including buildings, other constructions and other artificial surfaces.

Rural villages (Vr)

Artificial surfaces with rural area geographical aspect including buildings and other artificial surfaces.

Industrial and others (Ia)

Artificial surfaces including industrial areas and other artificial surfaces.

Infrastructure (I)

Artificial surfaces including infrastructure and other artificial surfaces.

Derived classes (second level)

A further sub-division is made for rural villages and infrastructure. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Bomas – Bo

Picture



Description

This class describes the generic aspect of bomas. It is constituted by one mandatory stratum that defines the overall class structure. The strata are constituted by three basic elements built up, herbs and bare area. The element built up has three attributes:

- Construction material: Light material.
- It is consisting of artificial surfaces that is buildings.

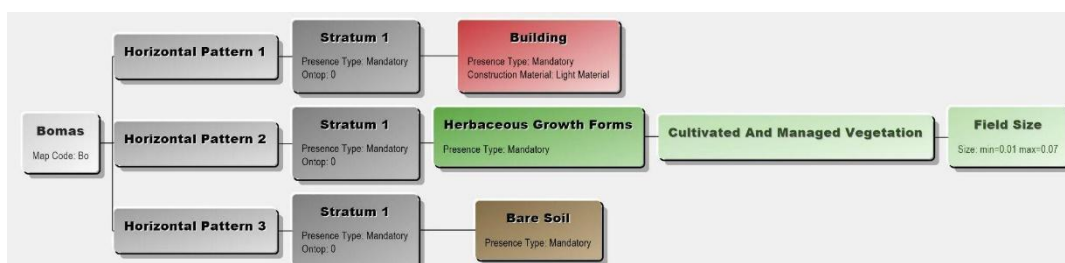
A strata of basic element herb is present with the following attributes:

- Herbaceous crops field size is 0.01 – 0.07 hectares.
- Vegetation artificiality defined as cultivated and managed vegetation.

A strata of basic element bare area with the following attributes:

- Presence type of artificial surface is bare soil.

LCCS diagram



Port – Po

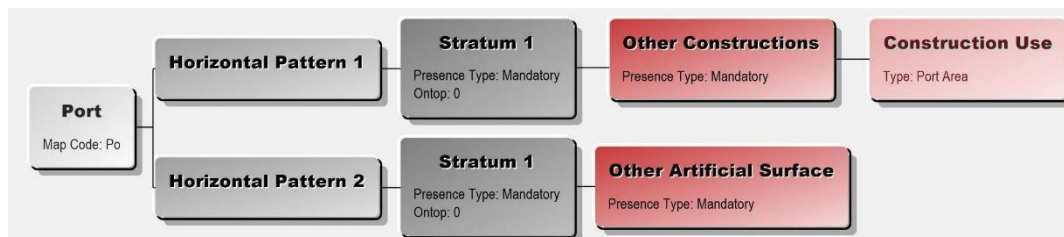
Picture



Description

It is a built up – nonlinear area for ships.

LCCS diagram



Airport - Ae

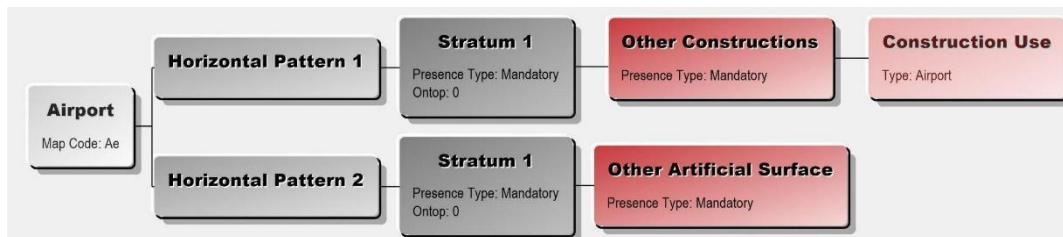
Picture



Description

It is a built-up nonlinear area which is used for flights to take off and land.

LCCS diagram



Class expansion for built-up non-linear

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

Physiognomic structural properties:

- **Height:** more specific height can be used to better characterize the basic element.

Other attributes:

- **Construction status:** status of the construction objects can be added.
- **Construction use:** type of construction use can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Built-up linear and others – Bla

It corresponds to artificial surface which are built-up linear.

Figure 29. LCCS diagram for built-up linear and others



Derived classes

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for built-up linear and others

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

- **Road type:** types of roads can be added.
- **Construction status:** status of the construction objects can be added.
- **Construction use:** type of construction use can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Dump sites and extraction sites – Sd

Land used for disposal of waste materials is known as dump sites. Extraction sites are defined by the absence of the original land cover which is removed by human activity or machinery for extraction of sand, stone, mineral or coal.

Figure 30. LCCS diagram for dump sites and extraction sites



Derived classes

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for dump and extraction sites

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

- **Cover:** cover percentage can be added for basic element.
- **Dump types:** types for dumps can be added.
- **Extraction type:** types for extraction sites can be added.

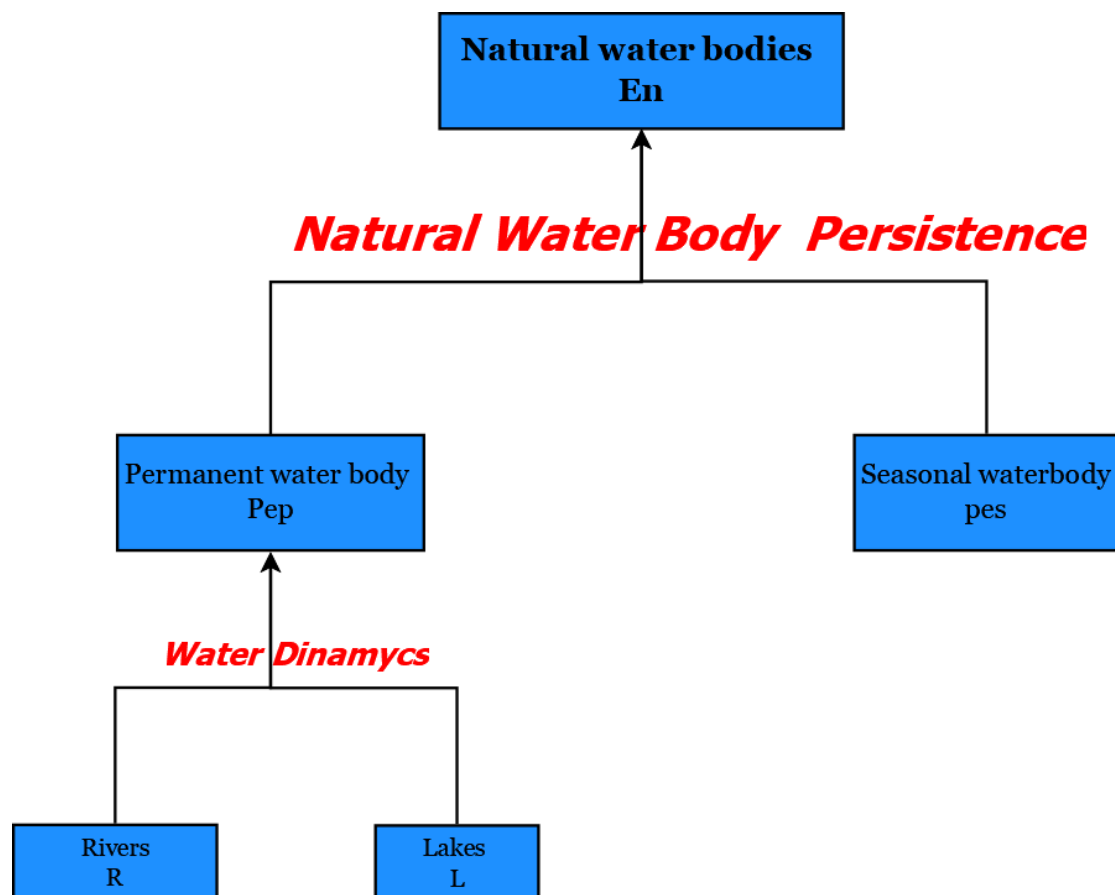
Section VIII

Natural waterbodies – Pen

Permanent Water body – Pep

It corresponds to natural water bodies which are permanent feature in an area. They are further categorized based on water dynamics.

Figure 31. Structure of permanent waterbodies



Derived classes (second level)

A further sub-division is made for permanent water body. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Rivers - R

Picture

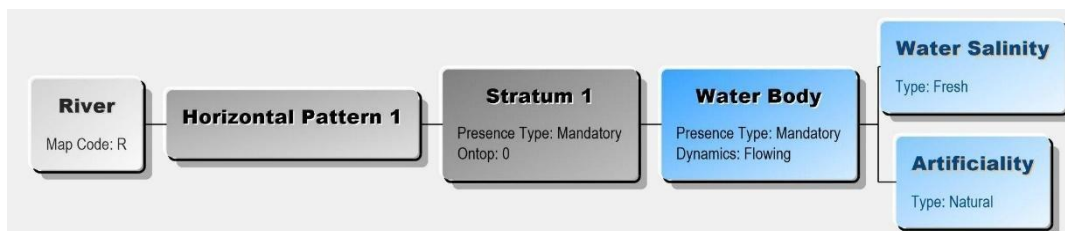


Description

The rivers are natural water courses which serves as water drainage channels. A basic element water body has following attributes:

- Water dynamics is flowing.
- Artificiality of water body is natural.
- Water salinity is fresh.

LCCS diagram



Lakes - L

Picture

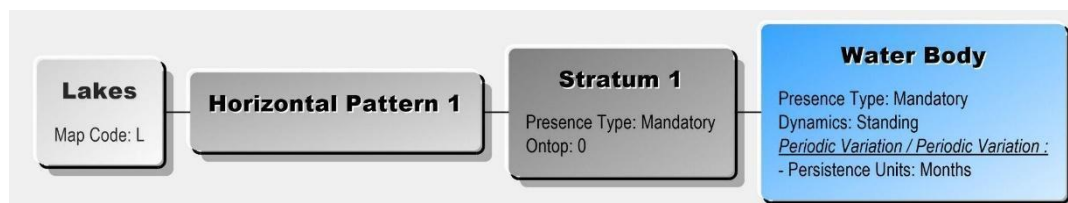


Description

A natural standing water reservoir that is bigger than a pond and has an irregular shape. This class consists of one mandatory strata. A basic element water body has following attributes:

- Monthly periodic variation.
- Water dynamics is standing.

LCCS diagram



Class expansion for permanent water body

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

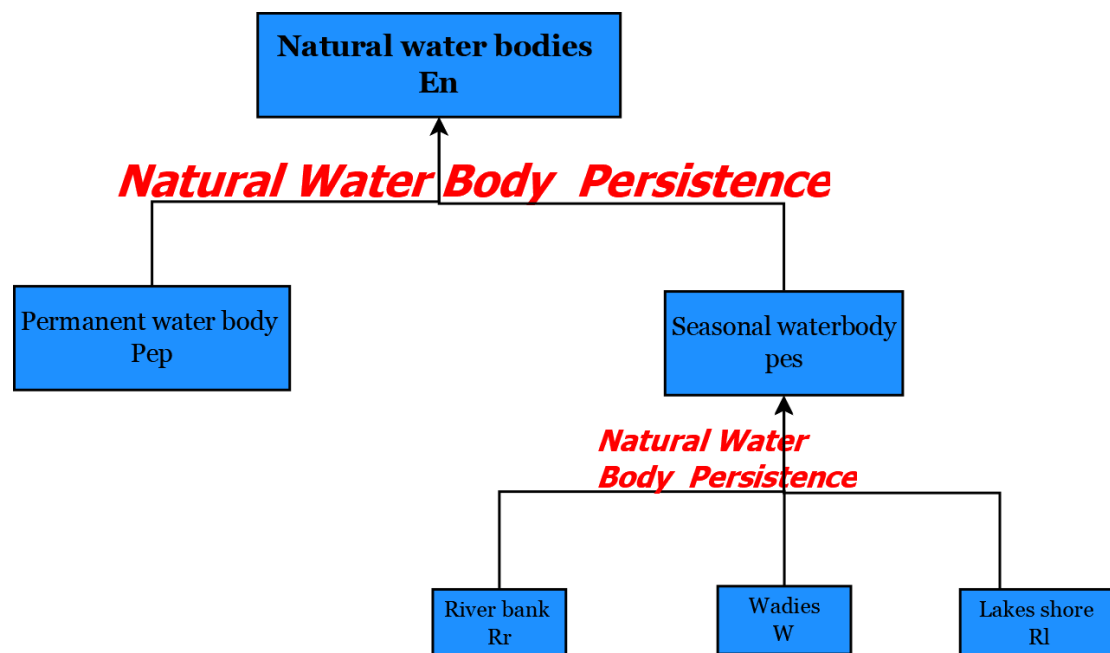
Other attributes:

- Water body dynamics: water type can be added that is flowing, or standing etc.
- Water body position: position of the waterbody can be added
- Water body: Water artificiality and salinity type can be further added.
- Water depth: Water depth can be added.

Seasonal Waterbodies – pes

It corresponds to natural water bodies which are seasonal in an area. They are further categorized based on natural water body persistence.

Figure 32. Structure of seasonal waterbodies



Derived classes (second level)

A further sub-division is made for seasonal water body. At this level the classes have a detailed structural aspect. A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Riverbank - Rr

Picture

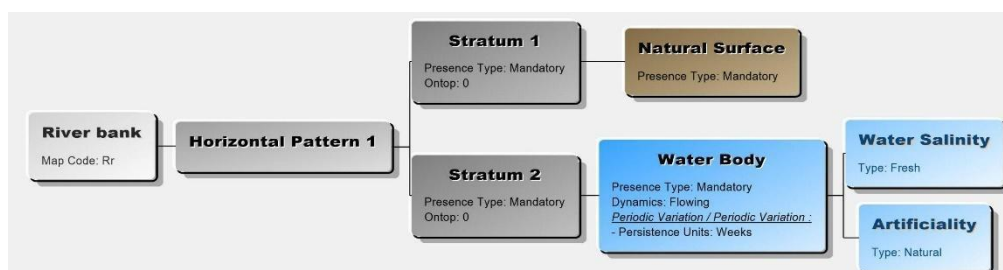


Description

The riverbank is the land alongside the bed of a river which is usually consists of soil and sand deposits and inundated when the river flows with the fully capacity. This class describe the generic aspect of riverbank. It is constituted by two mandatory strata that defines the overall class structure. The strata are constituted by one basic element water body. Another basic element natural surface is also present. The element water body has following attributes:

- Weekly periodic variation.
- Water dynamics is flowing.
- Artificiality of water body is natural.
- Water salinity is fresh.

LCCS diagram



Wadies - W

Picture

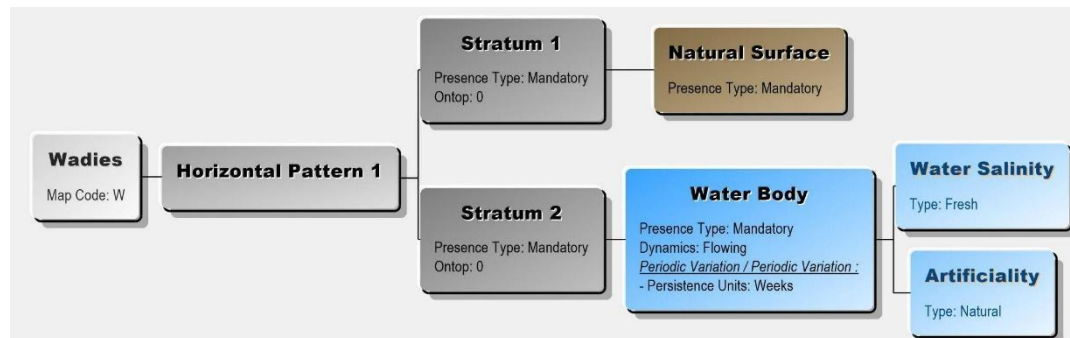


Description

This class describe the generic aspect of Wadi. It is constituted by two mandatory strata that defines the overall class structure. The strata are constituted by one basic element water body. Another basic element natural surface is also present. The element water body has following attributes:

- Weekly periodic variation.
- Water dynamics is flowing.
- Artificiality of water body is natural.
- Water salinity is fresh.

LCCS diagram



Lake shores - RI

Picture

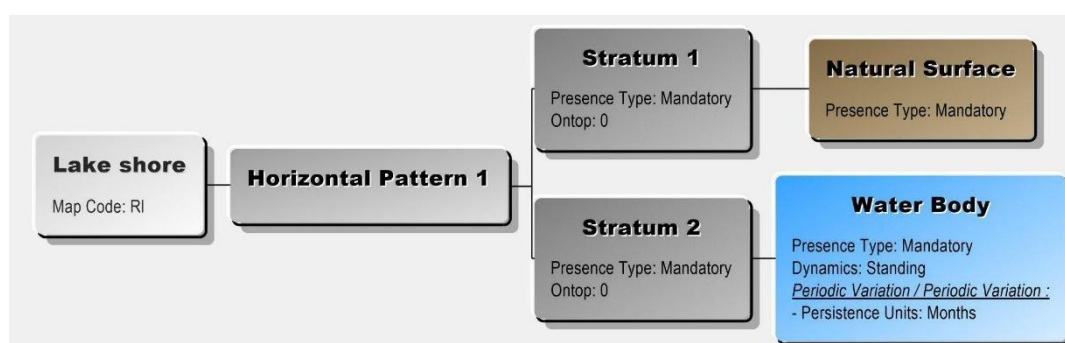


Description

This class describe the generic aspect of lake shores. It is constituted by two mandatory strata that defines the overall class structure. The strata are constituted by one basic element water body. Another basic element natural surface is also present. The element water body has following attributes:

- Weekly periodic variation.
- Water dynamics is standing.

LCCS diagram



Class expansion for seasonal waterbodies

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

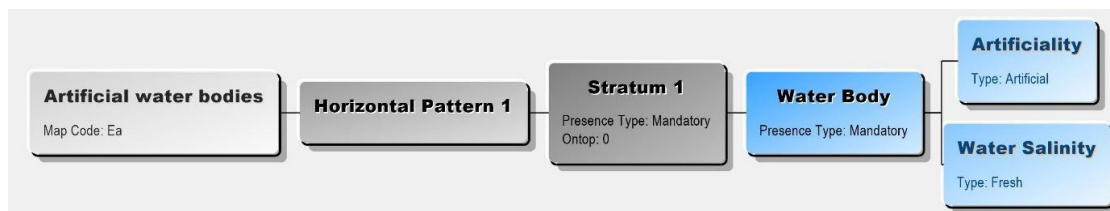
- **Water body dynamics:** water type can be added that is flowing, or standing etc.
- **Water body position:** position of the waterbody can be added.
- **Water body:** Water artificiality and salinity type can be further added.
- **Water depth:** Water depth can be added.
- **Water periodic variation:** Period type and persistence period can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Section IX

Artificial waterbodies - Ea

It corresponds to artificial water bodies which are permanent and/or seasonal feature in an area. Th UML diagram for artificial water bodies is provided in Figure 33.

Figure 33. LCCS diagram for artificial waterbodies



Derived classes (second level)

A further expansion of the thematic details can be done, if necessary, as listed in the class expansion section.

Class expansion for artificial waterbodies

The regional reference schema gives to the user a wide possibility to enrich the thematic details of each class. This can be done using the shared dictionary of attributes of the ISO standard LCML. Following this process, each further enrichment of legend categories will assure a full harmonization process of different legends that for different reasons (legend scope, terrain knowledge etc.) wants to have different thematic attributes to define their classes. In this specific context, the foreseen suggested class thematic enrichment attributes could be the following:

- **Water body dynamics:** water type can be added that is flowing, or standing etc.
- **Water body position:** position of the waterbody can be added.
- **Water body:** Water artificiality and salinity type can be further added.
- **Water depth:** Water depth can be added.
- **Water periodic variation:** Period type and persistence period can be added.
- **Any other attributes:** other attributes derived from the LCML shared dictionary.

Appendix B. Non exhaustive list of existing legends

Table 1. Non exhaustive list of existing legend

ID	Class name	Class description	Legend name	Geographic area	Reference
1	Forest	Dense, closed canopy formation of evergreen or semi-evergreen broadleaf vegetation with a multiple strata structure that includes scattered emergent trees. Upper stratum of trees over 30 m tall. Understory composed of evergreen or semievergreen shrubs; herbaceous cover is discontinuous.	West Africa land cover legend	West Africa	CILSS (2016)
2	Gallery forest & Riparian Forest	Forest formations forming a band or corridor of dense vegetation along permanent or temporary watercourses; generally closed canopy and similar in structure to forest; their width, extent, and luxuriance depend on the width, and depth of the valleys they follow, as well as the depth and dynamics of the water table. Riparian forest is similar in structure but is found bordering the edges of streams and rivers.	West Africa land cover legend	West Africa	CILSS (2016)
3	Degraded forest	Dense, evergreen broadleaf forest with closed or partially closed canopy whose integrity has been degraded by logging or other forms of exploitation. Degraded forest can also be immature forest, or forest in various stages of regrowth after disturbance. Trees 10 to 30 m tall.	West Africa land cover legend	West Africa	CILSS (2016)

ID	Class name	Class description	Legend name	Geographic area	Reference
4	Woodland	Open formations of small to medium height trees; tree height over 10 m and tree cover generally between 50 and 75 percent; canopies are often contiguous, with open areas between trees; grass understory can be scattered to dense, often associated with other herbaceous plants.	West Africa land cover legend	West Africa	CILSS (2016)
5	Swamp forest	Open to dense forests associated with temporarily or permanently waterlogged soils; these forests are generally found in natural depressions, seasonally inundated.	West Africa land cover legend	West Africa	CILSS (2016)
6	Plantation	Regular stands of trees planted for the purpose of producing food, beverages, vegetable oils, raw materials for industry, wood, or for protection against wind and water erosion.	West Africa land cover legend	West Africa	CILSS (2016)
7	Mangrove	Coastal forests of stilted shrubs or trees bordering the ocean or coastal estuaries, composed of one or several mangroves species.	West Africa land cover legend	West Africa	CILSS (2016)
8	Thicket	Dense stand of shrubs, often thorny, forming generally impenetrable cover, with minimal or no herbaceous ground cover.	West Africa land cover legend	West Africa	CILSS (2016)
9	Savanna	Herbaceous vegetation with mainly grasses that generally exceed 80 cm in height; dominated by annual and perennial grasses typically associated with the Sudan and Guinea zones; ground cover often consumed by annual fires; woody vegetation is usually	West Africa land cover legend	West Africa	CILSS (2016)

ID	Class name	Class description	Legend name	Geographic area	Reference
		present. The savanna class includes several major types or sub-classes, based on density of shrubs and trees; the land use/land cover maps do not distinguish between shrub savanna, tree savanna, and wooded savanna; nevertheless, it is useful to define them.			
10	<i>Shrub savanna</i>	Scattered shrubs dominate the woody vegetation, with continuous herbaceous cover usually dominated by grasses; woody cover between 1 and 25 percent.	West Africa land cover legend	West Africa	CILSS (2016)
11	<i>Tree savanna</i>	Scattered trees and shrubs with a continuous herbaceous understory usually dominated by grasses; woody cover between 1 and 25 percent.	West Africa land cover legend	West Africa	CILSS (2016)
12	<i>Wooded savanna</i>	Shrubs and trees in an open formation with a continuous herbaceous understory usually dominated by tall grasses; woody cover between 25 and 50 percent.	West Africa land cover legend	West Africa	CILSS (2016)
13	Herbaceous savanna	Continuous herbaceous ground cover; trees and shrubs normally absent; this class is represented on the land use/ land cover maps.	West Africa land cover legend	West Africa	CILSS (2016)
14	Sahelian short grass savanna	Scattered trees and shrubs (or only shrubs) with a continuous herbaceous understory usually dominated by annual grasses generally associated with the Sahelian zone; woody cover between 1 and 25 percent.	West Africa land cover legend	West Africa	CILSS (2016)

ID	Class name	Class description	Legend name	Geographic area	Reference
15	Bowe	Flat, open surfaces that generally occur as lateritic plateaus; the skeletal, ferruginous soils form a hardened, impenetrable surface, generally absent of woody vegetation, but supporting varying quantities of herbaceous cover during the rainy season. ground cover, often mixed with shrubs and trees; insufficient cover to carry fire; scattered annual grasses accompanied by widely spaced perennials	West Africa land cover legend	West Africa	CILSS (2016)
16	Steppe	Open, discontinuous herbaceous ground cover, often mixed with shrubs and trees; insufficient cover to carry fire; scattered annual grasses accompanied by widely spaced perennials.	West Africa land cover legend	West Africa	CILSS (2016)
17	Sandy area	Beach sand or shifting mounds of sand, formed by wind; active dunes.	West Africa land cover legend	West Africa	CILSS (2016)
18	Rocky land	Areas of rocky surfaces or outcrops, consisting of rocky peaks, batholiths, talus slopes, crest lines, cliffs, conglomerates, etc.	West Africa land cover legend	West Africa	CILSS (2016)
19	Bare soil	Land with little or no vegetation cover, exposing the soil; examples include eroded slopes, gravel plains, sebkhas, and badlands.	West Africa land cover legend	West Africa	CILSS (2016)
20	Settlements	Built up areas comprising human communities in a village, town or city.	West Africa land cover legend	West Africa	CILSS (2016)
21	Agriculture	Cultivated areas, with crops dependent on rainfall.	West Africa land cover legend	West Africa	CILSS (2016)

ID	Class name	Class description	Legend name	Geographic area	Reference
22	Irrigated agriculture	Cultivated areas where crops receive water through an irrigation system to support their growth without relying on rainfall.	West Africa land cover legend	West Africa	CILSS (2016)
23	Agriculture in shallows and recession	Cultivated areas in depressions or along riverbanks where crop development occurs as the waters recede during the dry season.	West Africa land cover legend	West Africa	CILSS (2016)
24	Cropland and fallow with oil palms	Cultivated areas, with scattered oil palms in the fields; crops are mainly dependent on rainfall	West Africa land cover legend	West Africa	CILSS (2016)
25	Open mine	Open pit where rock material is mined	West Africa land cover legend	West Africa	CILSS (2016)
26	Wetland – floodplain	Herbaceous or aquatic vegetation in permanent or semi-permanent wetlands and swamps.	West Africa land cover legend	West Africa	CILSS (2016)
27	Water bodies	Any area with permanent or semipermanent surface water.	West Africa land cover legend	West Africa	CILSS (2016)
28	Tiger Bush	This pattern is composed of regularly spaced densely vegetated bands interspersed with bare areas. The pattern is reminiscent of a tiger's fur; thus, it is commonly called tiger bush. These formations often extend over several square kilometers on plateaus. In West Africa, tiger bush landscapes are found in the Gourma region in Mali, in northern Burkina Faso, and in southwestern Niger. They are found almost exclusively on ferruginous plateaus with medium-textured soils and	West Africa land cover legend	West Africa	CILSS (2016)

ID	Class name	Class description	Legend name	Geographic area	Reference
		little or no sand. On the land use and land cover maps, it is generally included in the steppe class because of the discontinuous aspect of ground cover.			
29	Spotted bush	It is composed of shrubs and small trees in a “spotted” distribution of concentrated vegetation areas interspersed with bare areas. Spotted bush is similar to tiger bush, also occurring on plateaus and uplands in the Sahel Region. It also occurs on areas of medium-textured soils, with little or no sand cover. Spotted bush occurs where the slope gradients are very shallow — generally less than 0.2 percent gradient. Spotted bush occurs over tens of thousands of square kilometers in Niger, Burkina Faso, Mali, and Mauritania. On the land use and land cover maps, it is often included in the steppe class because of the discontinuous aspect of the ground cover, but it can also occur in the Sahel short grass savanna class when the proportion of grass and shrub cover is high relative to the bare areas.	West Africa land cover legend	West Africa	CILSS (2016)
30	Spotted bush with termite mounds	It is composed of shrubs and small trees in a “spotted” distribution, except that the bare areas are associated with both active and abandoned termite mounds. Termites build large, complex structures that significantly alter soil texture, structure, and nutrients. They alter the surrounding hydrology and vegetation structure.	West Africa land cover legend	West Africa	CILSS (2016)

ID	Class name	Class description	Legend name	Geographic area	Reference
		Termite mounds in West Africa tend to be large and bare, though some are found with certain species of shrubs. They may reach up to 7 m in height, and over 10 m in diameter at the base, often with a much larger erosional outwash pediment. This pediment is the bare spot clearly seen from the aerial view. Termite mound spotted bush covers tens of thousands of square kilometers in Senegal, Mali, Mauritania, Burkina Faso, Niger, and Chad.			
31	Wooded savanna with bamboo	This land cover is a type of wooded savanna with an understory dominated by savanna bamboo commonly called Bindura bamboo (<i>Oxytenanthera abyssinica</i>). Bindura bamboo often grows in dense, tall stands under the open tree canopy and tends to occur in localized areas. In West Africa it is found in the Sudanian Region but is also widespread across Africa from Senegal to Ethiopia, and south to United Republic of Tanzania and Mozambique.	West Africa land cover legend	West Africa	CILSS (2016)
32	Badlands and eroded landscapes	Badlands are highly eroded surfaces, included under the bare soil land cover class. They are predominantly the result of water erosion, usually driven by land use pressures that have removed some or all of the protective vegetation cover in the recent past. These pressures when combined with land that has a slight to moderate slope, the removal of vegetation cover can	West Africa land cover legend	West Africa	CILSS (2016)

ID	Class name	Class description	Legend name	Geographic area	Reference
		create conditions for the erosive power of water to remove the topsoil, creating deep gullies and degraded landscapes or “badlands”. This phenomenon has spread quickly in many areas across the Sahel and Sudanian regions in recent decades.			
33	Forest Islands	Forest islands are scattered among open savannas of south-central Guinea, particularly in the Kissidougou Region. They are generally circular, and most have a village at their center. The concentration of forest islands in Guinea is remarkable, but not unique in West Africa. They can be found in all of the southern tier countries. Among these, Benin stands out for its nearly 3 000 sacred forests— many of which resemble the forest islands of Guinea. Most are associated with a village, as seen in these oblique aerial views.	West Africa land cover legend	West Africa	CILSS (2016)
34	Moist forest	Closed stand with several strata, including an upper stratum of large trees, grass stratum generally absent or, if present, with species with broad leaves.	Yangambi land cover legend	West Africa	Yangambi (1956)
35	Dry deciduous forest	Closed stand with several strata, of lower stature than the preceding type; most trees of the upper strata deciduous; understory of shrubs evergreen or deciduous; grass stratum generally discontinuous.	Yangambi land cover legend	West Africa	Yangambi (1956)

ID	Class name	Class description	Legend name	Geographic area	Reference
36	Thicket	Shrubby vegetation, evergreen or deciduous, usually more or less impenetrable, often in clumps, with grass stratum absent or discontinuous.	Yangambi land cover legend	West Africa	Yangambi (1956)
37	Moist montane forest	Similar to moist forest at low and medium altitude, differing in the habit, smaller height of the trees and in other characters, including often greater abundance of epiphytic bryophytes.	Yangambi land cover legend	West Africa	Yangambi (1956)
38	Dry montane forest	Same definition as dry forest at low and medium altitudes, but with the upper stratum reduced in size. These forests are sometimes sclerophyllous.	Yangambi land cover legend	West Africa	Yangambi (1956)
39	Bamboo forest	Same definition as moist forest at low and medium altitudes.	Yangambi land cover legend	West Africa	Yangambi (1956)
40	Mangrove	Coastal forests of stilted shrubs or trees bordering the ocean or coastal estuaries, composed of one or several mangroves species.	Yangambi land cover legend	West Africa	Yangambi (1956)
41	Swamp forest	Open to dense forests associated with temporarily or permanently waterlogged soils; these forests are generally found in natural depressions, seasonally inundated.	Yangambi land cover legend	West Africa	Yangambi (1956)
42	Riparian forest	Forest formations forming a band or corridor of dense vegetation found bordering the edges of streams and rivers; generally closed canopy and similar in structure to forest; their width, extent, and luxuriance depend on the	Yangambi land cover legend	West Africa	Yangambi (1956)

ID	Class name	Class description	Legend name	Geographic area	Reference
		width, and depth of the valleys they follow, as well as the depth and dynamics of the water table.			
43	Woodland	Open formations of small to medium height trees; tree height over 10 m and tree cover generally between 50 and 75 percent; canopies are often contiguous, with open areas between trees; grass understory can be scattered to dense, often associated with other herbaceous plants.	Yangambi land cover legend	West Africa	Yangambi (1956)
44	Savanna	Herbaceous vegetation with mainly grasses that generally exceed 80 cm in height; dominated by annual and perennial grasses typically associated with the Sudan and Guinea zones; ground cover often consumed by annual fires; woody vegetation is usually present. The savanna class includes several major types or sub-classes, based on density of shrubs and trees; the land use/land cover maps do not distinguish between shrub savanna, tree savanna, and wooded savanna; nevertheless, it is useful to define them.	Yangambi land cover legend	West Africa	Yangambi (1956)
45	Steppe	Open, discontinuous herbaceous ground cover, often mixed with shrubs and trees; insufficient cover to carry fire; scattered annual grasses accompanied by widely spaced perennials.	Yangambi land cover legend	West Africa	Yangambi (1956)
46	Grassland	Sparse grassland without trees or shrubs.	Yangambi land cover legend	West Africa	Yangambi (1956)

ID	Class name	Class description	Legend name	Geographic area	Reference
47	Post-flooding	Post- flooding cultivation of herbaceous crops	Globcover legend	Global	Globcover (2009)
48	Irrigated croplands	Irrigated tree crops / Irrigated shrub crops / Irrigated herbaceous crops	Globcover legend	Global	Globcover (2009)
49	Rainfed croplands	Rainfed shrub crops // Rainfed tree crops // Rainfed herbaceous crops	Globcover legend	Global	Globcover (2009)
50	Mosaic cropland (50-70%) / vegetation (grassland, shrubland, forest) (20-50%)	Cultivated and managed terrestrial areas / Natural and semi-natural primarily terrestrial vegetation	Globcover legend	Global	Globcover (2009)
51	Mosaic vegetation (grassland, shrubland, forest) (50-70%) / cropland (20-50%)	Natural and semi-natural primarily terrestrial vegetation / Cultivated and managed terrestrial areas	Globcover legend	Global	Globcover (2009)
52	Closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m)	Broadleaved evergreen closed to open trees // Semi-deciduous closed to open trees	Globcover legend	Global	Globcover (2009)
53	Closed (>40%) broadleaved deciduous forest (>5m)	Broadleaved deciduous closed to open (100-40%) trees	Globcover legend	Global	Globcover (2009)
54	Open (15-40%) broadleaved deciduous forest (>5m)	Broadleaved deciduous (40- (20-10) %) woodland	Globcover legend	Global	Globcover (2009)

ID	Class name	Class description	Legend name	Geographic area	Reference
55	Closed (>40%) needleleaved evergreen forest (>5m)	Needleleaved evergreen closed to open (100-40%) trees	Globcover legend	Global	Globcover (2009)
56	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	Needleleaved evergreen (40-(20-10) %) woodland // Needleleaved deciduous (40-(20-10)%) woodland	Globcover legend	Global	Globcover (2009)
57	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	Broadleaved closed to open trees / Needleleaved closed to open trees	Globcover legend	Global	Globcover (2009)
58	Mosaic forest/shrubland (50-70%) / grassland (20-50%)	Closed to open trees / Closed to open shrubland (thicket) // Herbaceous closed to open vegetation	Globcover legend	Global	Globcover (2009)
59	Mosaic grassland (50-70%) / forest/shrubland (20-50%)	Closed to open shrubland (thicket) // Herbaceous closed to open vegetation / Closed to open trees	Globcover legend	Global	Globcover (2009)
60	Closed to open (>15%) shrubland (<5m)	Broadleaved closed to open shrubland (thicket)	Globcover legend	Global	Globcover (2009)
61	Closed to open (>15%) grassland	Herbaceous closed to very open vegetation // Closed to open lichens/mosses	Globcover legend	Global	Globcover (2009)
62	Sparse (>15%) vegetation (woody vegetation, shrubs, grassland)	Sparse trees // Herbaceous sparse vegetation // Sparse shrubs	Globcover legend	Global	Globcover (2009)

ID	Class name	Class description	Legend name	Geographic area	Reference
63	Closed (>40%) broadleaved forest regularly flooded - fresh water	Closed to open (100-40%) broadleaved trees on temporarily flooded land, water quality: fresh water // Closed to open (100-40%) broadleaved trees on permanently flooded land, water quality: fresh water	Globcover legend	Global	Globcover (2009)
64	Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded - Saline water	Closed to open (100-40%) broadleaved trees on permanently flooded land (with daily variations), water quality: saline water // Closed to open (100-40%) broadleaved trees on permanently flooded land (with daily variations), water quality: brackish water // Closed to open (100-40%) semi-deciduous shrubland on permanently flooded land (with daily variations), water quality: saline water // Closed to open (100-40%) semi-deciduous shrubland on permanently flooded land (with daily variations), water quality: brackish water	Globcover legend	Global	Globcover (2009)
65	Closed to open (>15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - fresh, brackish or saline water	Closed to open shrubs // Closed to open herbaceous vegetation	Globcover legend	Global	Globcover (2009)
66	Artificial surfaces and associated areas (urban areas >50%)	Artificial surfaces and associated areas	Globcover legend	Global	Globcover (2009)

ID	Class name	Class description	Legend name	Geographic area	Reference
67	Bare areas	Bare areas	Globcover legend	Global	Globcover (2009)
68	Water bodies	Bare areasNatural water bodies // Artificial water bodies	Globcover legend	Global	Globcover (2009)
69	Permanent snow and ice	Artificial perennial snow // Artificial perennial ice // Perennial snow // Perennial ice	Globcover legend	Global	Globcover (2009)
70	Large to Medium Tree Plantation	It describes rainfed plantations with size bigger than 2 hectares. It occurs mainly in the central and western Senegal, in particular Louga, Thies and Dakar regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
71	Large to Medium Tree Plantation – Casuarina sp. Plantations	It describes Casuarina (C.equisetifolia) plantations with size bigger than 2 hectares. The plantation water supply is rainwater. It is found all along the coastal area of Dakar, Thies and Louga regions. In fact, Casuarina is used to stabilize sand dunes, that occur all along the coast.	Senegal land cover legend	Senegal	Senegal land cover (2005)
72	Small Tree Plantation	Small Tree Plantation” describes rainfed plantations with size smaller than 2 hectares. The plantation water supply is rainwater. It occurs rarely in the central and western regions of Senegal to describe local situations.	Senegal land cover legend	Senegal	Senegal land cover (2005)
73	Large to Medium Tree crops	It describes permanent rainfed orchards with field size bigger than 2 hectares. It mainly refers to large mango and orange crops. It occurs in the western and southern portions of Senegal (Dakar, Thies, Fatick,	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
		Ziguinchor and Kolda regions).			
74	Small Tree crops	It describes rainfed orchards with field size smaller than 2 hectares. It occurs in western and southern portions of Senegal, and it mainly refers to mango and orange orchards. In Dakar, Thies, Fatick regions its detection is simple since it is often associated to rainfed herbaceous crops appearing, on the Landsat ETM images (RGB 432 composite), as dark red dots between the pink/light brown reflectance of the herbaceous fields. On the other hand, in Ziguinchor and Kolda regions, the reflectance of the orchards is almost the same of the natural trees covering the area; so, when this class is mixed with natural vegetation, its detection is difficult.	Senegal land cover legend	Senegal	Senegal land cover (2005)
75	Large to Medium Irrigated Banana crops	It describes banana crops with surface irrigation and field size bigger than 2 hectares. It is found only in the Tambacounda region, near the eastern Gambia border. The class was detected based on local staff knowledge. The zone where the class occurs neither is covered by Google Earth high resolution images, nor was checked during the field work verification.	Senegal land cover legend	Senegal	Senegal land cover (2005)
76	Large to Medium Rainfed Herbaceous crops	It describes rainfed single crops with field size bigger than 2 hectares. It is found mainly in Kaolack and Kolda regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
77	Small Rainfed Herbaceous crops	It describes rainfed single crops with field size smaller than 2 hectares. It occurs mainly in western Senegal (Dakar and Thies regions). Its reflectance is very similar to the one of the classes "Small Rainfed Herbaceous crops with a layer of sparse trees" with which could be confused. The crops are mainly constituted by peanuts. Secondly it is constituted by: millet, maize, sorghum, beans, rice (terrestrial).	Senegal land cover legend	Senegal	Senegal land cover (2005)
78	Small Rainfed Herbaceous crops – Isolated	It is representing a scattered-isolated spatial distribution, that is to say the percentage of fields is more than 10 percent but less than 20 percent of the whole polygon's area. It is always found as second term in mixed units. The crops are mainly constituted by peanuts; secondarily it is constituted by: millet, maize, sorghum, beans, rice (terrestrial).	Senegal land cover legend	Senegal	Senegal land cover (2005)
79	Large to Medium Rainfed Herbaceous crops with a layer of Sparse Trees.	It describes rainfed single crops with field size bigger than 2 hectares; inside the agricultural area is present a layer of natural trees having a cover ranging from 1% to 15%. The crops are mainly constituted by peanuts; secondarily it is constituted by: millet, maize, sorghum, beans, rice (terrestrial). It is found mainly in central Senegal (Kaolack, Diourbel and Louga regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
80	Small Rainfed Herbaceous crops with a layer of Sparse Trees	It describes rainfed single crops with field size smaller than 2 hectares; inside the agricultural area is present a layer of natural trees covering 1% to 15% of the area. The crops are mainly constituted by peanuts; secondarily it is constituted by millet, maize, sorghum, beans, rice (terrestrial). It is the more recurring class, and it is found all over Senegal. It covers great portion of Louga, Thies, Diourbel, Fatick and Kaolack regions, identifying the so called "Peanut Basin".	Senegal land cover legend	Senegal	Senegal land cover (2005)
81	Small Rainfed Herbaceous crops with a layer of Sparse Trees– Isolated	It is the just described class "Small Rainfed Herbaceous crops with a layer of Sparse Trees", representing a scattered-isolated spatial distribution, the percentage of fields is more than 10 percent but less than 20 percent of the whole polygon's area. It is always found as second term in mixed units. The crops are mainly constituted by peanuts. Secondarily it is constituted by millet, maize, sorghum, beans, rice (terrestrial).	Senegal land cover legend	Senegal	Senegal land cover (2005)
82	Large to Medium Irrigated Herbaceous crops	It describes irrigated single crops with field size bigger than 2 hectares. The crop is permanent, that is to say the same crop covers the land for at least two years. It occurs mainly in Dakar, Thies and Saint-Louis regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
83	Large to Medium Irrigated Herbaceous crops – Sugar Cane	It describes irrigated Sugar Cane crops having field size bigger than 2 hectares. The are two sequential crops where sequential indicates the growing of two or more crops in sequence on the same field within one growing season. The succeeding crop is planted after the preceding one is harvested. The fields are permanent (the same crop covers the land for at least two years) and the water supply is constituted by surface irrigation. It is found only in the northern portion of Senegal, in the Saint-Louis region.	Senegal land cover legend	Senegal	Senegal land cover (2005)
84	Small Irrigated Herbaceous crops	It describes irrigated crops with field size smaller than 2 hectares. Crops are usually constituted by vegetables. It is mainly found close to the coastal area of Dakar, Thies and Louga regions; it is also found close to the Senegal river in Saint Louis and Matam regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
85	Small Post Flooding Herbaceous crops	It describes permanent crops with field size smaller than 2 hectares. The water supply is post-flooding irrigation, meaning that after a river overflow, water has flooded the field; the water infiltrated into the soil is used intentionally as a water reserve for crop cultivation. The crop uses this water reserve for establishment. This class is typically located inside the Senegal river basin, along the riverbanks (Saint Louis, Matam and Tambacounda regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
86	Closed Trees	It describes a layer of broadleaved deciduous trees covering more than 65 percent of a defined area. The trees have a generic height ranging from 3 to 30 m. This class is found in the south of Senegal, covering great portion of Ziguinchor, Kolda and southern Tambacounda regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
87	Closed Gallery Forest	It describes a layer of broadleaved deciduous trees covering more than 65 percent of a defined area. It is the forest located along rivers or streams. Trees' height ranges from 14 to 30 m. This class is mainly found in the south of Senegal (Ziguinchor, Kolda and Tambacounda regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)
88	Open Trees	It represents a forest with an open coverage. It is described 1) a first layer of broadleaved deciduous trees with open (40 - 65%) cover, and a generic height (3 - 30 m); 2) a second shrubs layer with general open (15 - 65%) cover and height (0,3 - 5 m); 3) a third herbaceous layer with a closed to open (15 - 100%) cover and generic height (0,03 - 3 m); and 4) This class is found in the south of Senegal, covering great portion of Ziguinchor, Kolda and south-eastern Tambacounda regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
89	Open Gallery Forest	It represents the forest located along rivers and streams with open coverage, and it is described 1) a first layer of broadleaved deciduous trees with open (40 - 65%) cover and a generic height (3 - 30 m); 2) a second shrubs layer with general open (15 - 65%) cover and generic height (0,3 - 5 m); and 3) a third herbaceous layer with a closed to open (15 - 100%) cover and generic height (0,03 - 3 m). This class is found all over Senegal, but it is most represented in Kaolack, Matam and Tambacounda regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
90	Very Open Trees	It represents a woodland described 1) a first layer of broadleaved deciduous trees with a very open (15 - 40%) cover and a generic height (3 - 30 m); 2) a second shrubs layer with open (15 - 65%) cover and generic height (0,3 - 5 m); and 3) a third herbaceous layer with a closed to open cover (15 - 100%) and generic height (0,03 - 3 m). This class is found all over Senegal but is most represented in Tambacounda region.	Senegal land cover legend	Senegal	Senegal land cover (2005)
91	Very Open Trees in Mare Environment	It is described as the class "Very Open Trees", with the difference that it shows a fragmented spatial distribution. It means that even if the cover is very open, it is interrupted in the sense of Striped or Cellular fragmentation. It represents the portion of woody vegetation developed in the so called "Mare environment", i.e., small striped depressions in flat	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
		areas where the rainwater stands for short periods. This class is always present as mixed unit and it is generally associated with the class "2HOArE - Closed to Open Herbaceous vegetation with Sparse Trees and Shrubs". It is found in central and northern Senegal, covering great portions of Saint-Louis, Louga and Matam regions.			
92	Closed Shrubs	It describes a layer of broadleaved deciduous shrubs covering more than 65 percent of a defined area. The shrubs have a generic height ranging from 0.3 to 5 m. This class is not very representative and is mainly found in eastern Senegal (Tambacounda region). Woody vegetation with height lower than 5 meters belongs to the class shrubs. So, inside this class could be found also small trees.	Senegal land cover legend	Senegal	Senegal land cover (2005)
93	Open Shrubs with emergent Trees	It represents a shrubland, described as 1) a first layer of broadleaved deciduous shrubs with open (65 - 40%) cover and generic height (0.3 - 5 m); 2) a second herbaceous layer with a closed to open cover (15 - 100%) and generic height (0,03 - 3 m); and 3) a third trees layer with sparse (4- 15%) cover and generic height (3 - 30 m). This class is mainly found in south and eastern Senegal, covering great portions of Tambacounda, Kolda and Ziguinchor regions; it is also well represented in Thies region.	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
94	Open Shrubs	It represents a shrubland, described as 1) a first layer of broadleaved deciduous shrubs with open (65 - 40%) cover and generic height (0.3 - 5 m); and 2) a second herbaceous layer with a closed to open (15 - 100%) cover and generic height (0.03 - 3 m). It is derived from the just described class 2arOAE, in order to define an open shrubland where emergent trees are not present or negligible. During the fieldwork, this class was mainly observed as protected areas surrounded by agricultural areas. This class is found all over Senegal, but it is not very frequent. It is most represented in Tambacounda region.	Senegal land cover legend	Senegal	Senegal land cover (2005)
95	Very Open Shrubs with emergent Trees	It represents a shrubland, described as 1) a first layer of broadleaved deciduous shrubs with very open (40 - 15%) cover and generic height (0.3 - 5 m); 2) a second herbaceous layer with a closed to open cover (15 - 100%) and generic height (0.03 - 3 m); and 3) a third trees layer with sparse (4 - 15%) cover and generic height (3 - 30 m). This class is mainly found in southern and eastern Senegal, covering great portions of Tambacounda, Kolda and Ziguinchor regions; it is also well represented in Thies region.	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
96	Very Open Shrubs	It defines a shrubland described as 1) a first layer of broadleaved deciduous shrubs with very open (40 to 15%) cover, and generic height (0.3 - 5 m); and 2) a second herbaceous layer with closed to open cover (15 - 100%) and generic height (0.03 - 3 m). It is derived from the just described class 2arTOAE, in order to define a very open shrubland where emergent trees are not present or negligible. During the fieldwork, this class was mainly observed as protected areas surrounded by agricultural areas. This class is found all over Senegal, but it is not very frequent. It is most represented in Kaolack and Tambacounda regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
97	Closed to Open Herbaceous vegetation with Sparse Trees and Shrubs	It represents a grassland described as 1) a first herbaceous layer with closed to open (40 -100%) cover with generic height (0.03 - 3 m); 2) a second trees layer with sparse (4 - 15%) cover and generic height (3 - >30 m); and 3) a third shrubs layer with sparse (4 - 15%) cover and generic height (0.3 - 5 m). This class is one of the more recurring and it is found all over Senegal. It is most represented the central and north of Senegal, and it covers great portions of Saint-Louis, Louga, Diourbel, Matam and Kaolack regions. In northern Senegal it is often associated to the class "very open trees in mare environment"	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
98	Closed to Open Herbaceous vegetation	It represents a grassland described as an herbaceous layer with closed to open (40 - 100%) cover and generic height (0.03 - 3 m). This class is found all over Senegal, but it is most represented in Thies, Matam and Tambacounda regions. The interpretation of this class was often problematic because of the similar reflectance with the class "closed to open herbaceous vegetation with sparse trees and shrubs"	Senegal land cover legend	Senegal	Senegal land cover (2005)
99	Large to Medium Rice crops	It describes rice crops with field size bigger than 2 hectares. It represents an aquatic or regularly flooded cultivated area with graminoids crops. During the cultivation period the water persists the whole day. One herbaceous terrestrial additional crop grows in sequence on the same field within one growing season, but the main crop is rice. The succeeding crop is planted after the preceding one is harvested. It is found along the Senegal river in northern and eastern Senegal. It is mainly located in the Saint-Louis region, even if could be found also in Matam and Tambacounda regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
100	Small Rice crops	It describes rice crops with field size smaller than 2 hectares. It represents an aquatic or regularly flooded cultivated area with graminoids crops. In this case crops grow in waterlogged depressions and the agricultural practices are not linked to mechanized farming. It is	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
		mainly found in southern Senegal (Ziguinchor and Kolda regions), even if could be also found in Fatick and Saint-Louis regions. It is located all along streams and rivers.			
101	Open Trees temporarily flooded – Gonakie	It defines an <i>Acacia Nilotica</i> sp. woodland with open (15 – 65%) cover and generic height (3 - >30 m); it is flooded with fresh water from 2 to 4 months per year. It is located in the valley floor, along the rivers (on the banks) and it is locally known with the term “Gonakie”. This class is present in the northern and eastern part of Senegal (Saint-Louis and Matam regions), inside the Senegal river basin. Given that is not possible to determine the length of water permanence with a single satellite image, sometimes, in the geographic contest described above, this class could have been coded as terrestrial open woodland (2AO) or vice versa.	Senegal land cover legend	Senegal	Senegal land cover (2005)
102	Closed to Open Shrubs temporarily flooded	It defines shrubland with cover ranging from 15 to 100%, and medium height (0.5 - 5 m); it is flooded from 2 to 4 months per year. It is located in the valley floor, along the rivers and in the depressions. This class is mainly present in the northern and eastern part of Senegal (Saint-Louis and Matam regions), inside the Senegal river basin. It is also present in the Fatick region’s flooded areas. Given that is not possible to determine the length of water permanence with a	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
		single satellite image, sometimes, in the geographic contest described above, this class could have been coded as terrestrial open shrubland (2arO, 2arOAE, 2arTO, 2arTOAE) or vice versa.			
103	Closed to Open Mangrove Shrubs	It defines a layer of Rizophora sp. shrubs with cover ranging from 40 to 100%, and general height (0.3 - 5 m); it is flooded in permanence (more than 4 months per year) with brackish water, having a daily variation. It is located in delta environment.	Senegal land cover legend	Senegal	Senegal land cover (2005)
104	Closed Herbaceous vegetation permanently flooded	It defines a layer of tall (0,8 - 3 m) herbaceous vegetation with closed (> 65%) cover; it is flooded with fresh water for more than 4 months per year. It is located in the valley floor, along lake or riverbanks and in the depressions. This class is present in the northern and eastern part of Senegal (Saint-Louis, Louga and Matam regions), inside the Senegal river basin. It is also present in the flooded areas of the Fatick region.	Senegal land cover legend	Senegal	Senegal land cover (2005)
105	Closed to Open Herbaceous vegetation permanently flooded with brackish water	It defines a layer of halophilic herbaceous vegetation with closed to open (40 - 100%) cover and generic height (0.03 – 3 m); it is flooded with brackish water for more than 4 months per year. It is located in delta environment. This class is present in western Senegal (Fatick and Kaolack regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
106	Closed to Open Herbaceous vegetation temporarily flooded	It defines a layer of herbaceous vegetation with closed to open (40 - 100%) cover and generic height (0.03 – 3 m); it is flooded with fresh water from 2 to 4 months per year. It is located in flat areas of valley floor geomorphologic context. This class is mainly present in northern and north-western Senegal, inside the Senegal river basin (Saint-Louis and Matam regions), but it occurs also in the other wet areas of the country.	Senegal land cover legend	Senegal	Senegal land cover (2005)
107	Urban Area(s)	It defines a nonlinear built-up area covered by impervious structures adjacent to or connected by streets. This cover is related to centers of population. Linear elements like (main) roads, railways and communication lines/pipelines occur but are not a dominant feature. It refers to all the cities and towns of Senegal.	Senegal land cover legend	Senegal	Senegal land cover (2005)
108	Airport	A complex of runways and buildings for the take-off, landing, and maintenance of civil aircraft, with facilities for passengers.	Senegal land cover legend	Senegal	Senegal land cover (2005)
109	Port	A town or city with a harbour or access to navigable water where ships load or unload.	Senegal land cover legend	Senegal	Senegal land cover (2005)
110	Rural Settlements	It defines a nonlinear built-up area. It refers to the villages in the rural area of Senegal.	Senegal land cover legend	Senegal	Senegal land cover (2005)
111	Mines and Quarries	It refers to all the extraction sites of Senegal	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
112	Bare Soil	It refers to any bare soil and/or unconsolidated material.	Senegal land cover legend	Senegal	Senegal land cover (2005)
113	Sand	It occurs mainly along the coastal area and in northern Senegal (Saint-Louis and Louga regions). This class is often associated to Mare environment.	Senegal land cover legend	Senegal	Senegal land cover (2005)
114	Sand Dunes	It defines loose and shifting sand moved by the wind and occur rarely only along the coastal area of Dakar, Thies and Louga regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
115	Bare Soil affected by Water Erosion	It defines bare soil and/or unconsolidated material resulting from a water erosion process. Scattered (cover < 4%) vegetation may be present. The life forms composing this type of vegetation can be any life form and, due to their scattered distribution, it is difficult to further specify them. It occurs mainly in northern and north-eastern Senegal, inside the Senegal river basin and along rivers and streams of Saint-Louis, Matam, Kaolack and Tambacounda regions.	Senegal land cover legend	Senegal	Senegal land cover (2005)
116	Salt Extraction	It is defined as an artificial waterbody of very saline shallow water whose persistence is more than 9 months per year. When water is not present, the surface is salt. This class occurs in the Saloum delta area, (Fatick and Kaolack regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)
117	River	It defines flowing fresh water whose persistence is more than 9 months per	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
		year. This class is found all over Senegal.			
118	Lake	It defines standing fresh water whose persistence is more than 9 months per year. This class is found all over Senegal.	Senegal land cover legend	Senegal	Senegal land cover (2005)
119	Salty Lake	It defines standing saline water whose persistence is more than 9 months per year. This class occurs in western Senegal.	Senegal land cover legend	Senegal	Senegal land cover (2005)
120	Non-Perennial Salty Lakes	It defines standing saline water whose persistence is less than 9 months per year. When water is not present, the surface is sand. This class occurs rarely along the coastal area, in western Senegal (Thies region).	Senegal land cover legend	Senegal	Senegal land cover (2005)
121	Tidal Area	It defines a bare soil affected by a regular rise and fall in the level of the sea. This class occurs principally in the delta environments of western Senegal (Saint-Louis, Fatick and Ziguinchor regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)
122	Bare Soil temporarily flooded	It defines a bare soil periodically affected by floods; the water persistence ranges from 1 to 3 months per year. This class occurs principally both in the delta areas and inside the Senegal river basin.	Senegal land cover legend	Senegal	Senegal land cover (2005)

ID	Class name	Class description	Legend name	Geographic area	Reference
123	Bare Soil OR Sparse Shrubs and Herbaceous vegetation in temporarily flooded area	It defines an area affected by floods of fresh water, where the water persistence ranges 2 to 4 months per year. The cover could be either bare soil, or sparse (1 - 15%) shrubs with a layer of sparse (5 - 15%) herbaceous vegetation. This class was used whenever it was not possible to distinguish between the two classes described above. It occurs principally in northern Senegal inside the basin of Senegal river (Saint-Louis, Matam and Tambacounda regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)
124	Bare Soil OR Sparse Shrubs and Herbaceous vegetation in temporarily flooded area – Brackish water	It defines an area affected by floods of salty water, where the water persistence ranges 2 to 4 months per year. The cover could be either sand, or sparse (1 - 15%) shrubs with a layer of sparse (5 - 15%) herbaceous vegetation. This class was used whenever it was not possible to distinguish between the two classes described above. It occurs principally in the delta environments of western Senegal (Saint-Louis, Fatick and Ziguinchor regions).	Senegal land cover legend	Senegal	Senegal land cover (2005)
125	Major urban	Densely populated city core	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
126	Minor urban	Smaller urban centres and the outskirts of large cities which are less densely populated than the city core	Nigeria land use legend	Nigeria	Nigeria land cover (1998)

ID	Class name	Class description	Legend name	Geographic area	Reference
127	Intensive (row crops, minor grazing) small holder rainfed agriculture	This type of agriculture refers to a vegetation and ground management regime which includes slash and burn clearing, non-mechanized planting and fertilization, replacement of all ground vegetation and most or all replacement of natural tree and shrub cover. Shrubs/trees include only those with agricultural products/use. Shrubs are usually absent in this class. Methods of planting, fertilizing, fallow, and field management vary within the country.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
128	Extensive (grazing, minor row crops) small holder rainfed agriculture	Extensive small holder rainfed agriculture is characterized by areas where grazing is the predominant agricultural activity with minor areas of fragmented, small holder row crop agriculture. In general, the native grasses, shrub and tree layer are intact but have been impacted on by grazing animals and fuel wood collection. This type of agriculture is not commonly associated with southern areas of the country where the population and pressures on the land base are greater.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
129	Extensive small holder rainfed agriculture with denuded areas	Characterized by disturbed areas of grasses and shrubs with areas of exposed bare soil.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)

ID	Class name	Class description	Legend name	Geographic area	Reference
130	Floodplain agriculture	Characterized by fragmented agricultural activity located within a river's floodplain.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
131	Rainfed arable crops	Characterized by large individual fields (>25 ha) mostly grain cropping, which is not irrigated, and mechanized farming techniques are used.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
132	Irrigation project	Characterized by large individual fields, separated by manmade irrigation canals.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
133	Livestock project	Characterized by uniform grassy fields with minor shrub areas.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
134	Agricultural tree crop plantation	Characterized by a large area under cultivation.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
135	Dominantly trees/woodland/shrubs with a subdominant grass component	Characterized by woodland savanna (trees and shrubs) and tree savanna (trees and shrubs are scattered).	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
136	Dominantly shrubs and dense grasses with a minor tree component	Characterized by a dense shrub and grass layer with a minor tree component.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
137	Dominantly grasses with discontinuous shrubs and scattered trees	Characterized by a dominant grass layer with thorny shrubs.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
138	Grassland	Characterized by dense grass cover with the shrub and tree component removed as a result of human activity.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)

ID	Class name	Class description	Legend name	Geographic area	Reference
139	Discontinuous grassland	Characterized by grasses interspersed with patches of bare soil.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
140	Montane grassland	Characterized by tussocky, flat-leaved grasses (0.6 to 1 m high) such as <i>Andropogon distachyos</i> and shrubs in crevices or stream channels.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
141	Undisturbed forest	Characteristically stratified into three layers: 1) the upper or emergent layer (40 to 50 m high) consists of scattered, very tall trees that do not form a continuous canopy, 2) the middle layer (16 to 40 m high) is also discontinuous, but taken together with the upper layer forms a continuous canopy, and 3) the lower tree layer (10 to 16 m high) forms a more or less continuous canopy.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
142	Disturbed forest	Characterized by areas of native forest with open canopies that are a result of human disturbance.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
143	Riparian forest	Characterized by its location adjacent to watercourses and its dense, closed canopy.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
144	Montane forest	Characterized by a tree canopy that is often irregular and discontinuous.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
145	Forest plantation	Large plantations of both exotic and indigenous tree species.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
146	Teak/Gmelina plantation	Large plantations of exotic tree species with pure and intermixed plantations.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)

ID	Class name	Class description	Legend name	Geographic area	Reference
147	Graminoid/sedge freshwater marsh	Characterized by freshwater wetland communities that occur in flood plains; on or adjacent to islands in large rivers; and in shallows of major lakes and rivers.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
148	Shrub/sedge/graminoid freshwater marsh/swamp	Characterized by freshwater wetland communities that occur in floodplains, on or adjacent to islands in large rivers, and in shallows of major lakes and rivers.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
149	Forested freshwater swamp	Most extensive freshwater wetland type found in Nigeria. Typically, the main canopy is rather open and, in the gaps, dense tangles of shrubs and lianes form an almost impenetrable undergrowth.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
150	Mangrove forest	Occurs on the muddy banks of creeks and in tidal channels in the upper portion of the zone of saltwater influence where the water is brackish.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
151	Saltmarsh/tidal flat -	Occurs at the uppermost limit of the tidal zone immediately inland of the Rhizophora mangrove forest. Flooded by saltwater only during the highest spring and neap tides.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
152	Natural waterbodies: ocean, river, lake	This class includes lakes, rivers, large streams, and the Atlantic Ocean.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
153	Canal	Manmade waterways used for transportation or irrigation.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)

ID	Class name	Class description	Legend name	Geographic area	Reference
154	Reservoir	Lakes created by damming rivers and streams.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
155	Rock outcrop	Exposed rock outcroppings with little to no vegetation.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
156	Sand dunes/aeolian	Exposed sand dunes formed by wind (aeolian) processes and susceptible to further erosion and movement.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
157	Alluvial	Sand and gravel deposits found within and adjacent to major rivers.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
158	Gullies	Areas substantially eroded by runoff following the removal of natural vegetation.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
159	Mining areas	Characterized by open pits.	Nigeria land use legend	Nigeria	Nigeria land cover (1998)
160	Infrastructure	It contains main roads and railways	Nigeria land use legend	Nigeria	Nigeria land cover (1998)

Appendix C. Using legend file when deriving a legend from West African Land Cover Reference System

Step 1. LCCS regional file

Regional file in. lccs can be downloaded from FAO LCLR (FAO, 2021)

Step 2 - Download and install in LCCS3 software into computer

This step describes how to download and install LCCS3 step-by-step.

- Download step

The overview of the main functionalities of the Land Cover Classification System software version 3 (LCCS3) version 1.8.0 Release (18.03.2015) and Java application can be found at: <http://www.geovis.net/>.

Direct links for required software are below:

LCCS3:

http://www.tngis.com/DownloadGeoVIS/LCCS/Lccs3_Setup_183_2015_07_23.zip

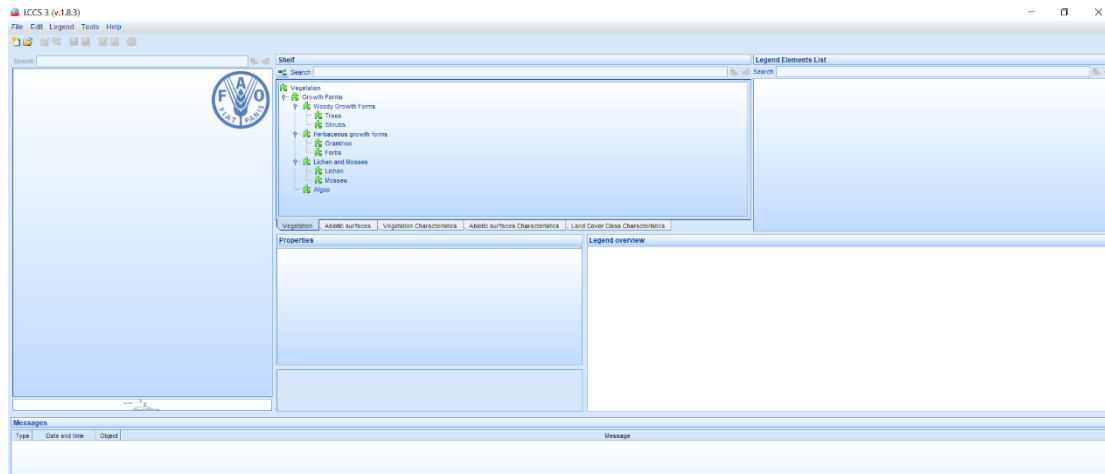
Java application:

http://www.tngis.com/DownloadGeoVIS/Service/JRE-1_6_0_14-windows-i586-s.zip

- Installation step

After downloading and uncompressing and installing the LCCS3 version 1.8.0 Release (18.03.2015) run it by clicking on the icon 

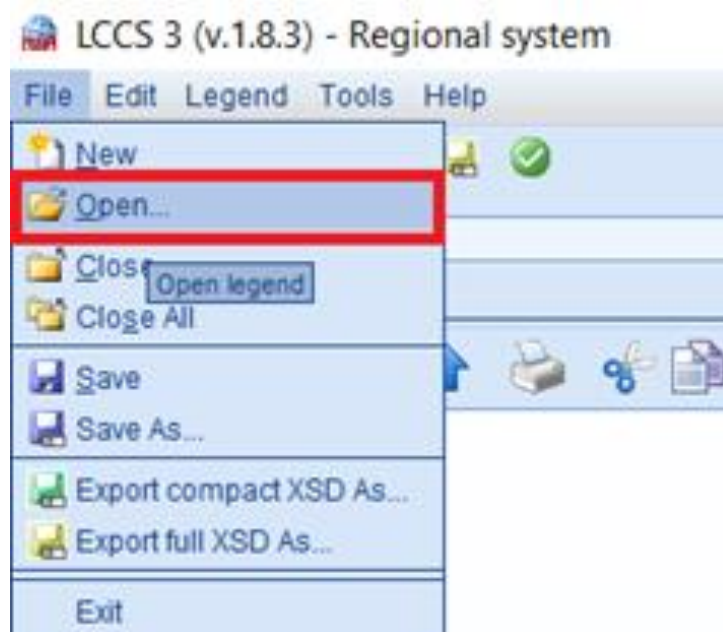
The application window will open, as shown below



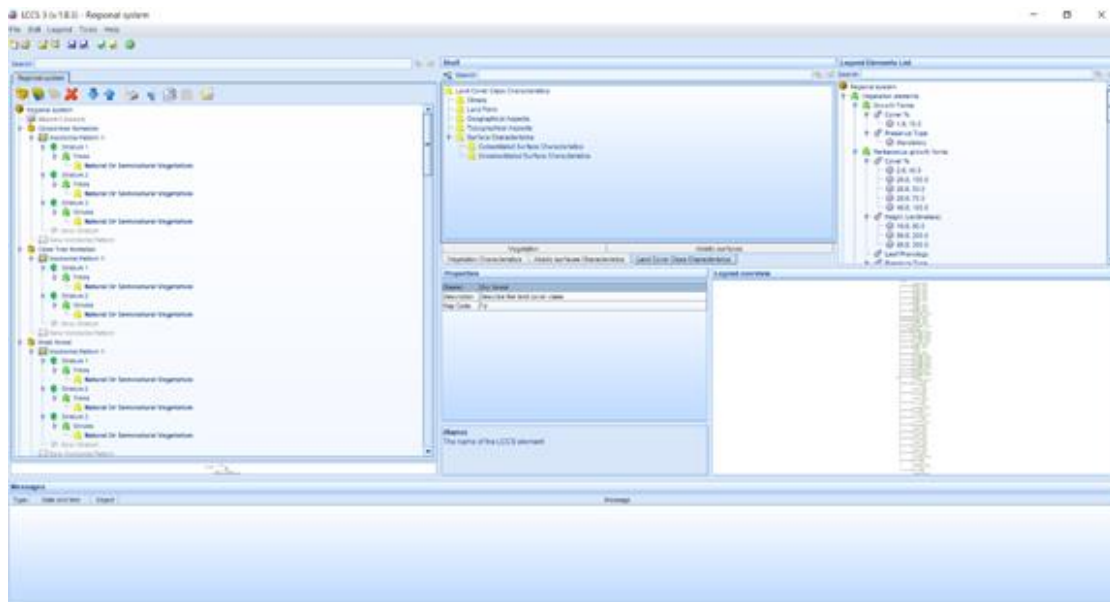
Step 3 - Loading LCCS regional file into LCCS3 software

After installing LCCS 3 software and LCCS regional file, load file in the software and create/modify national or local legend:

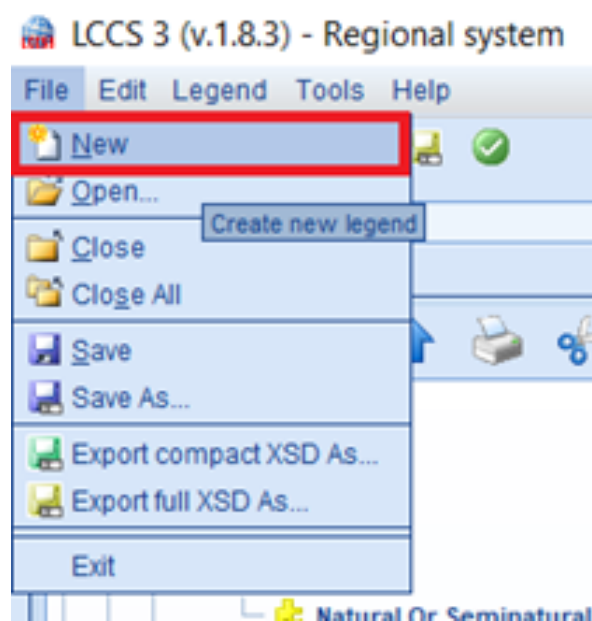
- Open LCCS3 software and click on file - > open (LCCS file: .lccs)



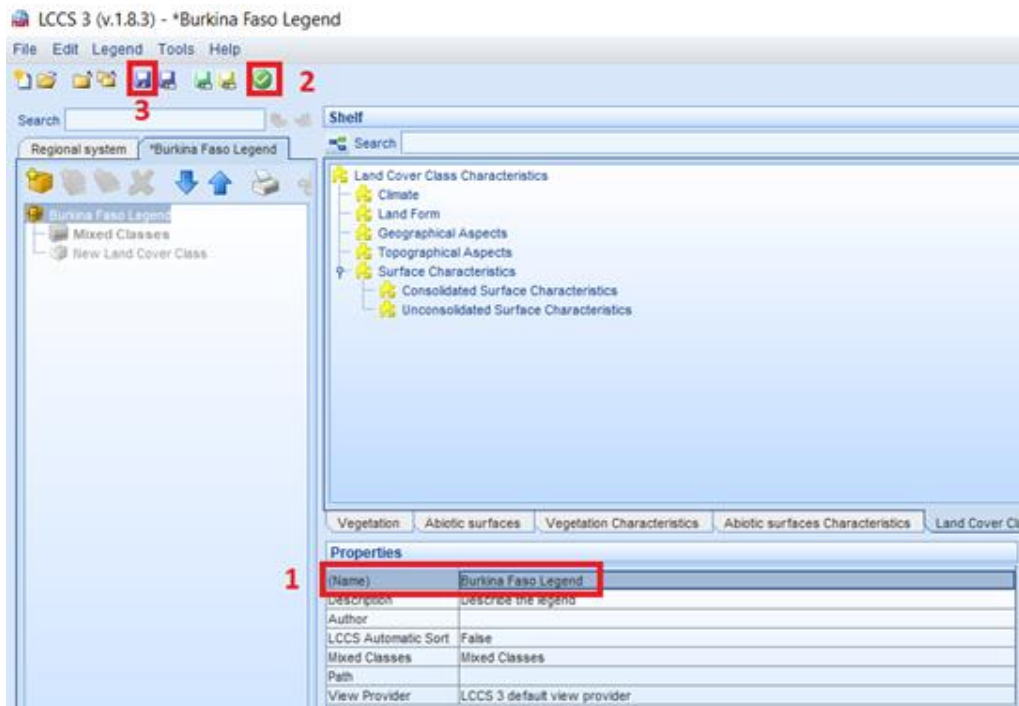
- File will be open in software as seen below.



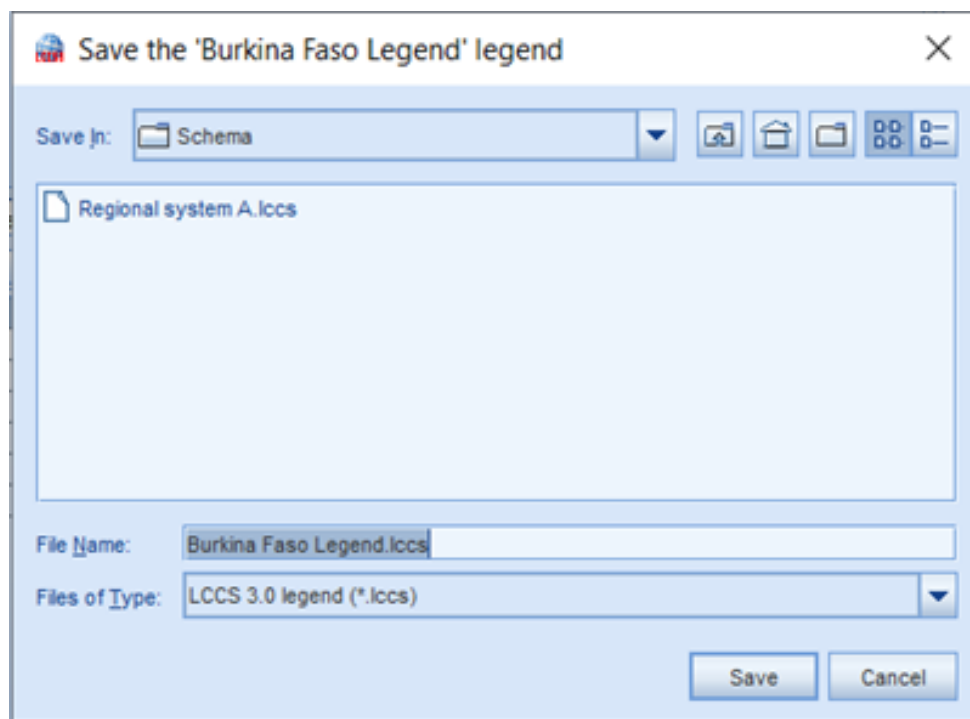
- Now click on the file -> New



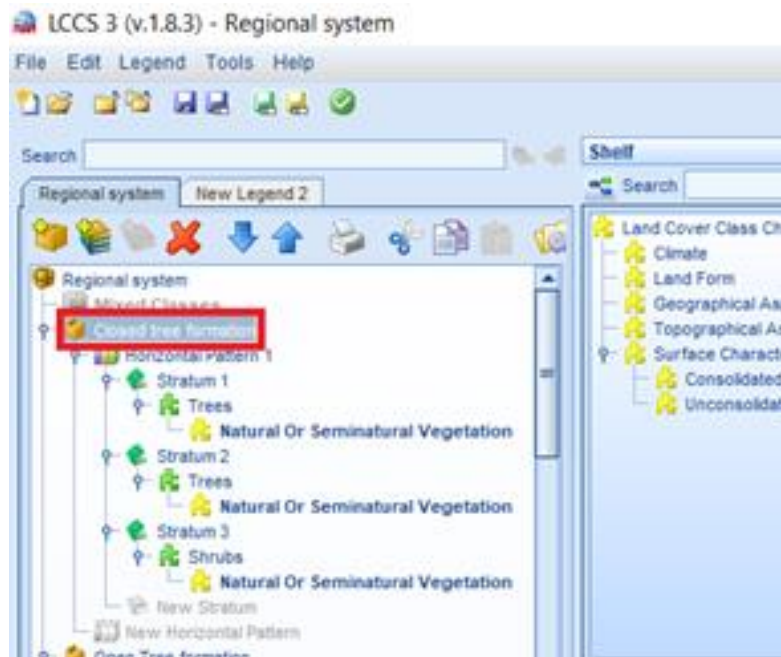
- Edit name of the legend (1), validate (2) and save it in LCCS format (3).



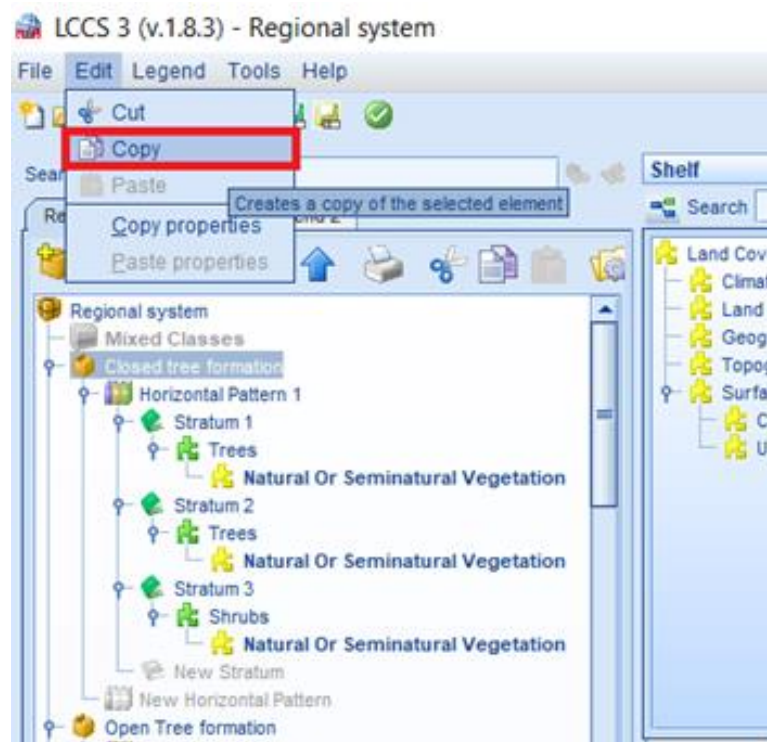
- While saving a legend a new window will open. Give the folder path and click on save.



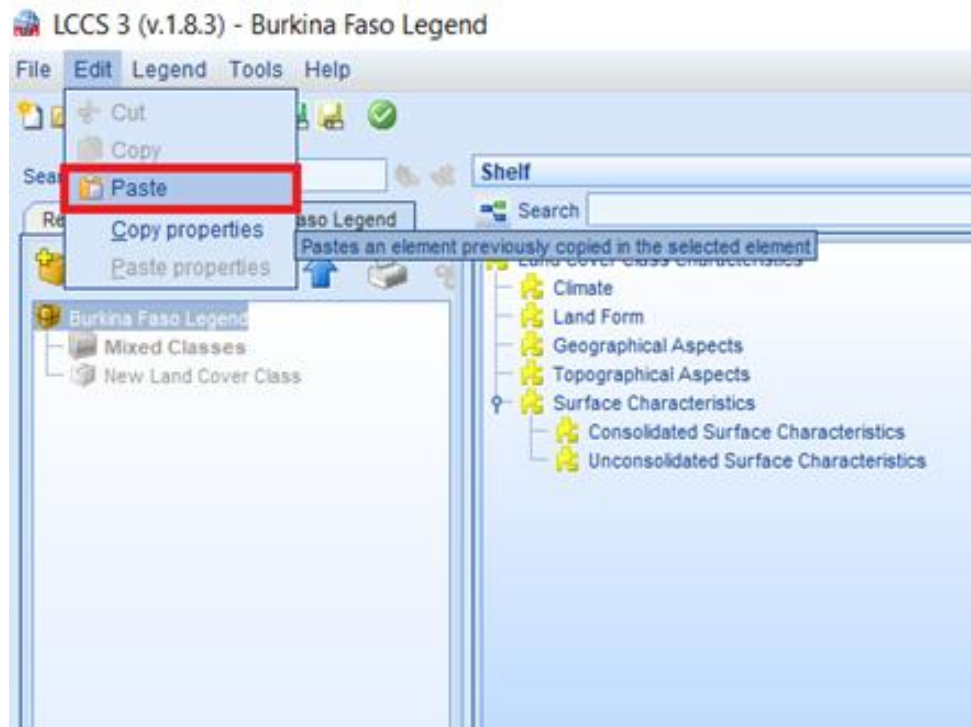
- After saving a new legend, click on the regional file tab and select the required class.



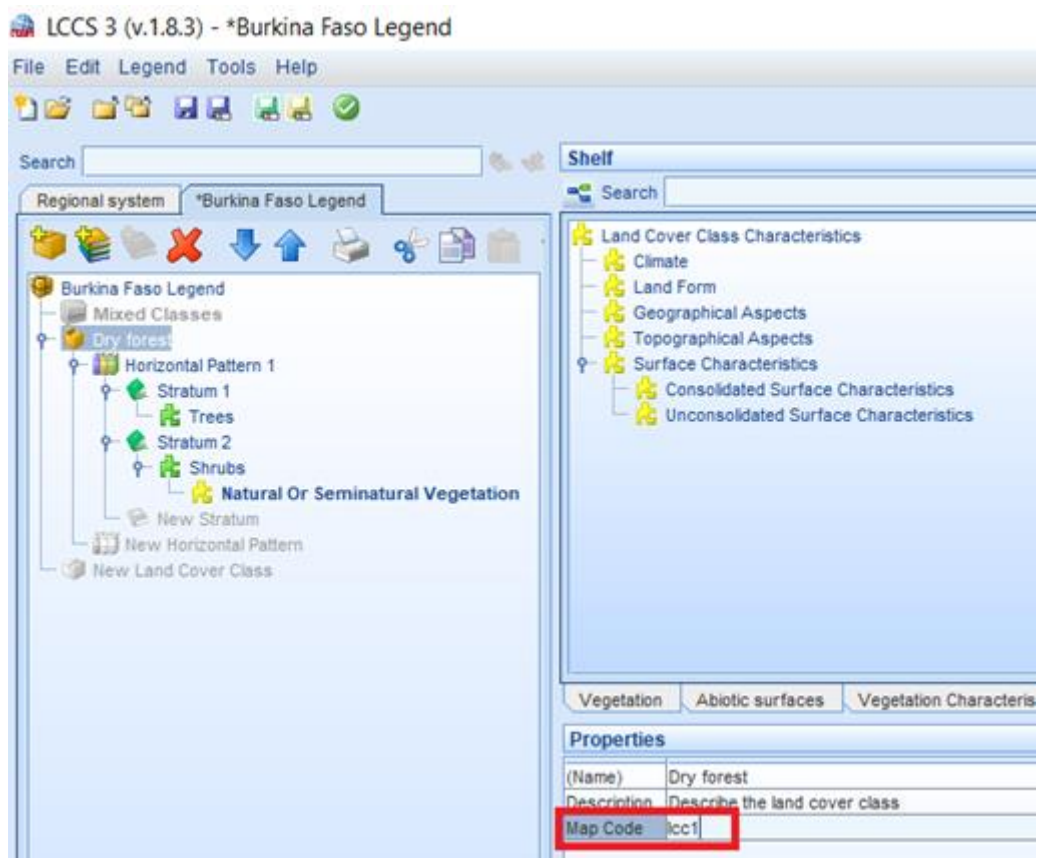
- Click “edit” and copy selected class



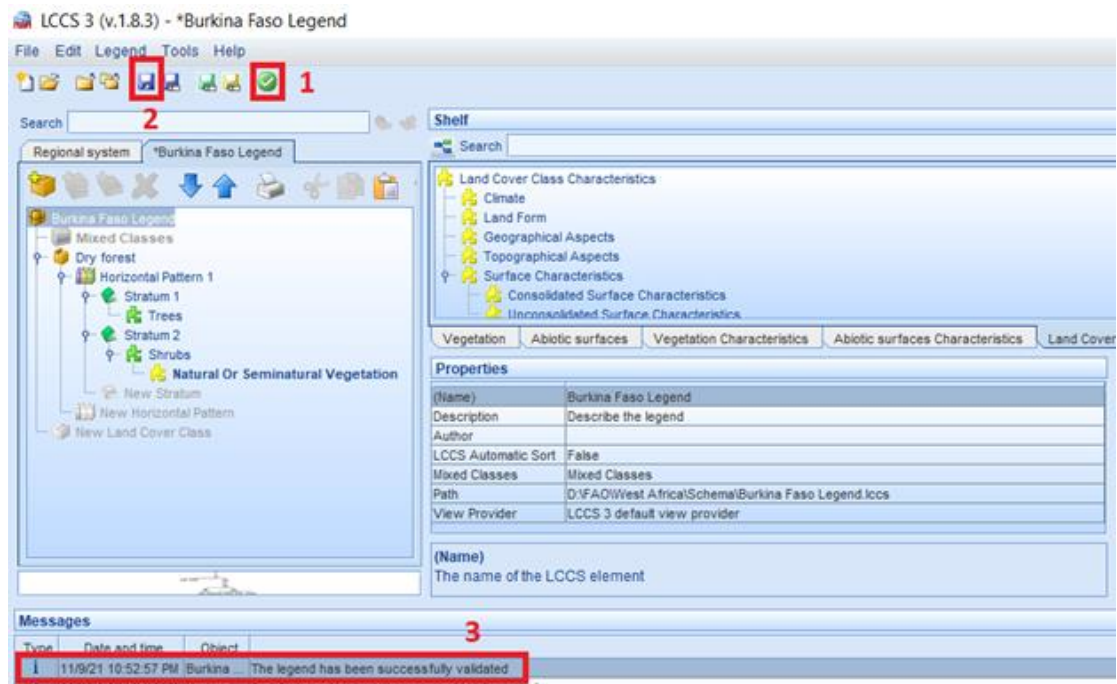
- Paste this class in a new file (named: “Burkina Faso Legend”). (Please be careful about the sequence of the classes while copying and pasting it in the new legend)



- After pasting class in new legend file, edit map code if you want to change class attributes / additional detail to specific class



- Users can add further details / features / attributes to a meta class.
- Each time the user provides detail to the meta class, click on validate button (1). It will give notification in message section (3). In case of validation click on save button (2). Class will be updated and saved in given path.



For further detail please refer to the LCCS user manual document (Di Gregorio, A., 2016).

West African Land Cover Reference System

This is the first land cover reference system for West Africa and is developed in collaboration with national and regional institutions. The system attempts to instantiate all these basic requirements in an innovative logical framework adapted and refined for West African countries. The system offers the possibility of a regional framework for land cover while ensuring interoperability between different derived classification or legends developed by different countries or different ministries and for different purposes. The system is designed to be flexible enough to adapt and evolve with needs.

In addition to creating specific legends for different applications, the system can also be used to make comparisons with other existing classifications. Furthermore, the land cover reference system for West Africa offers promising potentials for integrating land cover monitoring and field data collection initiatives for one of fundamental geospatial data themes.



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